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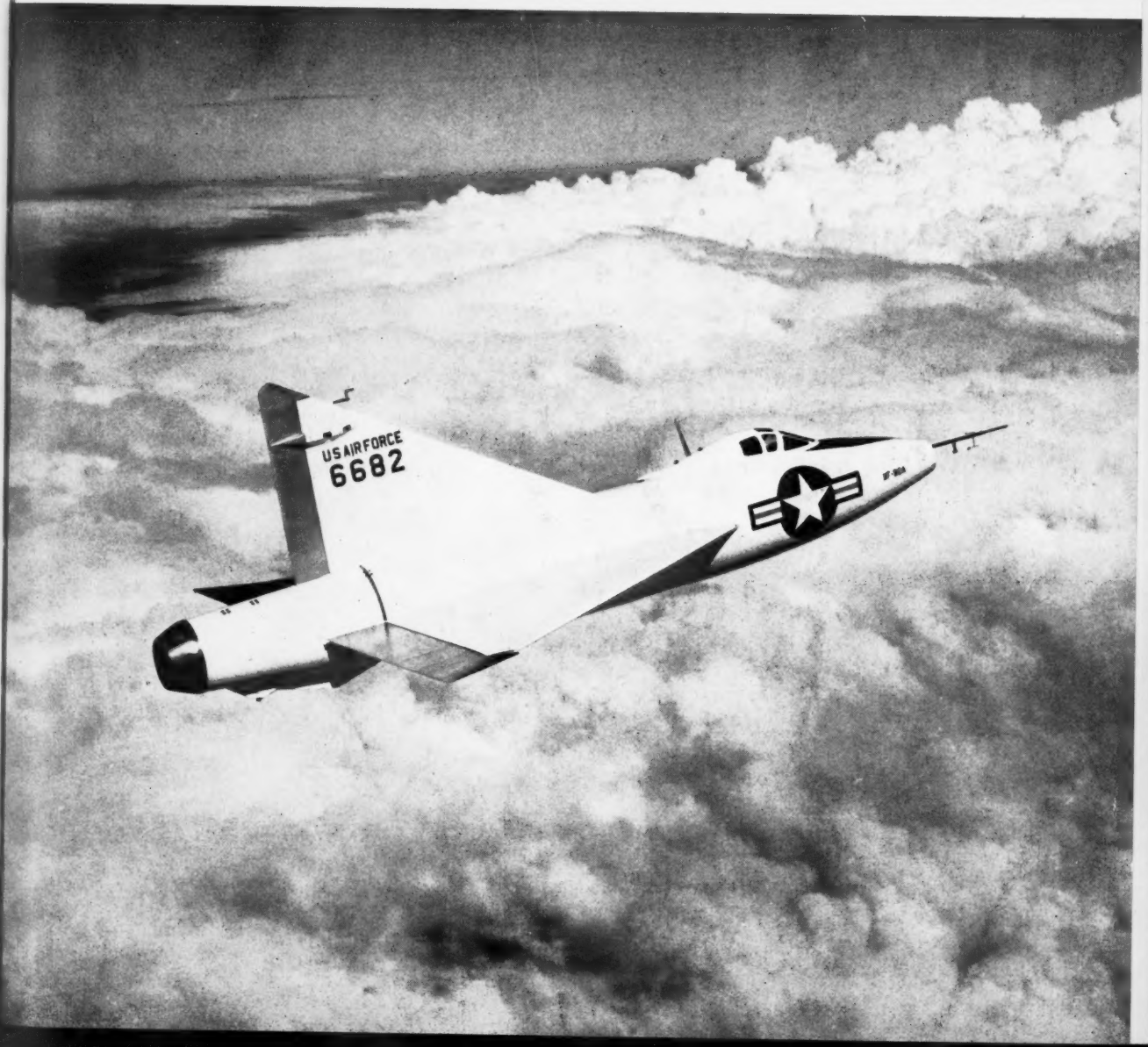
JULY 1952



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Cover—Consolidated Vultee Aircraft Corporation's XF-92A equipped with afterburner is shown in flight a short time before its scheduled delivery to the N.A.C.A. The XF-92A, which made its initial flight on September 18, 1948, was designed and built by Convair as an experimental ship to explore and test flight characteristics of a true delta wing.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 11 **JULY, 1952** **No. 7**

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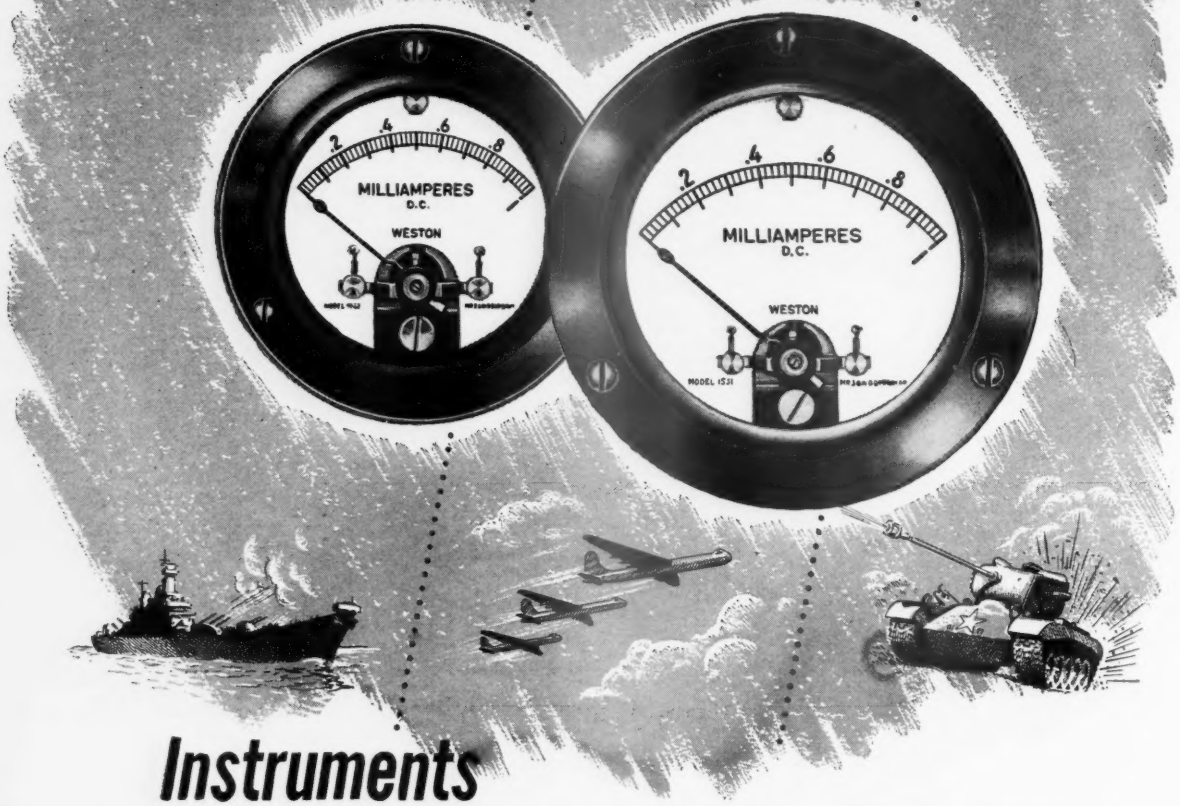

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I. A. S. News

A Record of People and Events of Interest to Institute Members

Doolittle Reports

President's Airport Commission Reports to President Truman 4 Days Ahead of Schedule

THE PRELIMINARY REPORT OF THE President's Airport Commission was delivered to the President of the United States, Harry S. Truman, at noon on Friday, May 16, or 4 days ahead of the 90-day time limit originally set. When the report was submitted, Lt. Gen. James H. Doolittle, U.S.A.F.R., I.A.S. Past-President, Honorary Fellow, and Founder Member, and Vice-President and Director of Shell Oil Company, who chairmanned the Airport Commission, pointed out to the President that not only had the report been finished within the prescribed time but that the Commission had not used all of the funds that had been allotted to it for the operation.

With General Doolittle at the time the report was delivered to President Truman were the other two members of the commission—Dr. Jerome C. Hunsaker, I.A.S. Past-President, Honorary Fellow, and Founder Member, and former Head of M.I.T.'s Department of Aeronautical Engineering; and Charles F. Horne, H.M.I.A.S., C.A.A. Administrator—and the Commission's Executive Director, S. Paul Johnston, I.A.S. Director and Fellow.

The following is a part of the report submitted by the President's Airport Commission and deals with "Organization and Procedures":

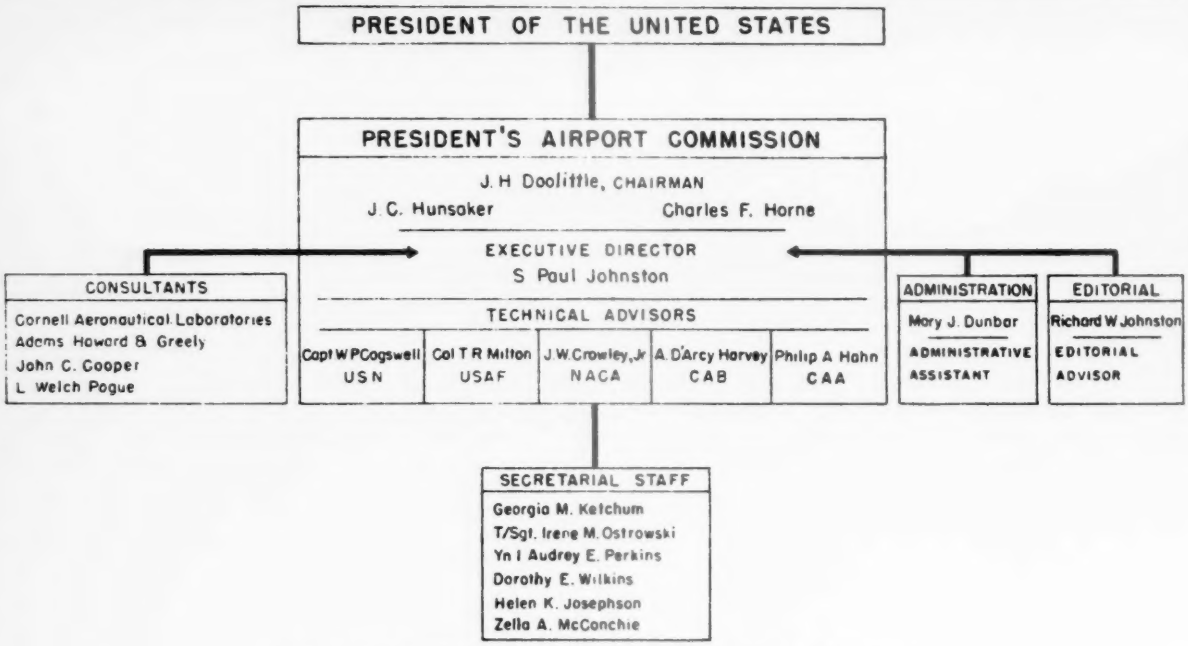
"The President's Airport Commission was organized under a Presidential directive issued at the White House on February 20, 1952. Members of the Commission met with the President in the White House to receive his personal instructions at noon on that day.

"The first full meeting of the Commission was held on Tuesday, February 26. In the interim, the several advisors from the military services, from the Civil Aeronautics Administration, the Civil Aeronautics Board and from the National Advisory Committee for Aeronautics had been appointed, and an operations and organization plan had been drawn up. The Department of Commerce undertook to perform the housekeeping and servicing functions for the Commission. Thanks to its cooperation, office space was promptly assigned, efficient stenographic and secretarial help was detailed, telephone services were provided and the Commission was actually in business by the day following its first meeting. Organizational meetings were held in late February and a working schedule was developed.

"In the period March 4 to March 24, a large number of organizations, both within Government and without, met with the Commission to give their views on the problem before it. During the same period, a questionnaire was forwarded to the mayors of 104 cities of the United States where airports were considered critical, either from the standpoint of population or high traffic density. All organizations that were known to have an interest in the airport problem were requested to submit written statements for Commission use on or before April 7. The response from both the cities and the interested organizations was most gratifying and yielded much valuable information.

"On March 25, 26 and 27, the Commission conducted a series of meetings

Lieutenant General James H. Doolittle, U.S.A.F.R., points out a passage to President Harry S. Truman in the report of the President's Airport Commission. Present are Dr. Jerome C. Hunsaker (*seated*) and (*standing from left to right*) Charles F. Horne; Major Gen. Robert B. Landry, Presidential Air Aide; and S. Paul Johnston.



ORGANIZATION—PRESIDENT'S AIRPORT COMMISSION.

in New York City in which the National Air Transport Coordinating Committee, the Port of New York Authority, and the Offices of the Mayor of New York, and the Mayor of Newark gave the Commission their views on the situation in that critical area. A number of civic organizations which had protested the continued existence of the Newark and New York airports on the grounds of hazard and nuisance were also heard.

"Between March 28 and April 5, the Commission and its staff made a nine-day survey of 16 major airports throughout the United States. The program included conferences with Mayors and/or other officials of Atlanta, New Orleans, Fort Worth, Dallas, Wichita Falls, San Diego, Los Angeles, Burbank, Long Beach, San Francisco, Oakland, Colorado Springs, Denver, Kansas City, St. Louis and Chicago. The U.S. Air Force supplied an airplane and crew for this trip. This courtesy saved much time for the Commission.

"During April, the Chairman conducted conferences and field inspections at Miami and Minneapolis. Mr. Horne inspected airports and held consultations with territorial official in Hawaii and with city officials in Honolulu, Seattle, Portland and Spokane. Mr. Hunsaker visited the Boston area for a similar purpose, and Mr. Hunsaker and Mr. Doolittle inspected the civil and military airports in the Washington-Baltimore area. Also, staff teams visited Pittsburgh, Cleveland, Detroit and Philadelphia. Alaskan airport problems were discussed in Washington with Alaska's Governor, the Honorable Ernest Gruening. Altogether some 30 airports in the United States were personally inspected by the Commission or its staff. These inspections were extremely valuable in supplementing the statistical data that had been furnished by the mayors of the several cities in response to the questionnaire.

"During the month of April, meetings with various government and airport organizations were continued in Washington. Meanwhile, supplementary written statements were received from many of the organizations which had been consulted during March and these were analyzed.

"In the course of its study, the Commission consulted with some 264 individuals and received written or oral statements from 42 organizations.

"All written material submitted and transcripts or summaries of conferences are filed with the records and working papers of the Commission."

A chart of the organization of the Commission and its staff is shown above.

The Editorial, which will be found on pages 20 and 21, covers some of the major recommendations set forth by the President's Airport Commission.

Printed copies of the full report are now on sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25; Price, $0.70.

News of Members

▸ **Donald W. Douglas,** I.A.S. Founder Member and Honorary Fellow, President and Chairman of the Board, Douglas Aircraft Company, Inc., has been re-elected a member of the board of the National Industrial Conference.

▸ **Sherman M. Fairchild,** I.A.S. Founder Member, Benefactor, and Fellow, recently described the Fairchild Flight Analyzer, developed by Sherman Fairchild & Associates, Inc. The Flight Analyzer, a camera that traces the path of a moving air plane on an 8- by 10-in. photographic plate, ostensibly permits faster and more accurate flight testing of commercial and military aircraft than has been previously possible. Mr. Sherman stated, "We feel that the Flight Analyzer has an important contribution to make to aviation and to national defense." The device is currently being tested by Grumman Aircraft Engineering Corporation. Mr. Fairchild is President of Sherman Fairchild & Associates, Director of Fairchild Engine & Airplane Corporation, and Chairman of the Board of Fairchild Camera & Instrument Corporation.

NEW APPOINTMENT

George S. Cherniak (M.) was recently named Vice-President of Engineering, Control Engineering Corporation. In this capacity, he is responsible for the corporation's engineering operations, including the development of new products and applications of existing products and facilities to new problems. Prior to this appointment, Mr. Cherniak was Executive Engineer, Anderson-Nichols & Company.

▸ **Maurice A. Garbell** (A.F.), President, Maurice A. Garbell, Inc., and Garbell Research Foundation, has authored Garbell Aeronautical Series No. 4, *The Timing of Airport Traffic Control As Influenced by Weather and Aircraft Performance*. The volume was put out by Garbell Research Foundation. The meteorological study, sponsored by the Air Navigation Development Board, was conducted under contract with the U.S. Weather Bureau; the aircraft performance study was sponsored by the Foundation.

▸ **Glenn L. Martin,** I.A.S. Founder Member, Honorary Fellow, and Benefactor, was honored by his home town of Santa Ana, Calif., at the dedication on April 30 of Santa Ana's new elementary school named in his honor. The Glenn L. Martin School is decorated with a series of murals that depict the entire history of Martin aircraft from the first plane, built and flown by Mr. Martin in 1909 (from a Santa Ana field), through the Martin planes of both World Wars, to the planes and missiles now in production at The Glenn L. Martin Company, of which Mr. Martin is Honorary Chairman of the Board. During the dedication ceremonies, the Santa Ana Junior Association of Commerce presented Mr. Martin with a certificate in recognition of his outstanding contributions to the progress and development of aviation.

▸ **Ralph H. McClarren** (A.F.) is now acting as Consulting Engineer with a professional office at 1500 Walnut Street, Philadelphia 2, Pa. He is specializing in aircraft, aircraft accessories, new product development, and personnel problems in these fields. Mr. McClarren was formerly Associate Director in charge of Electrical Engineering and Aviation at the Franklin Institute.

▸ **Juan T. Trippe,** I.A.S. Founder Member and Associate Member, President, Pan American World Airways, Inc., was awarded the French Legion of Honor as the founder of "the world's largest air transport company" and for making an outstanding contribution to the aviation industry. The presentation was made by Jean de Lagarde, French Consul General, on April 17.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of I.A.S. members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

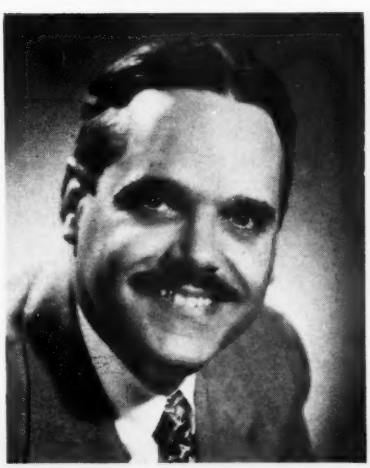
Roger G. Archambault (T.M.), Field and Service Representative, Northrop Aeronautical Institute. Formerly, Flight Test Analyst "A," Aerophysics Laboratory, North American Aviation, Inc.

Albert E. Arslan (M.), Technical Design Consultant, Northrop Aircraft, Inc. Formerly, Design Engineer, North American Aviation, Inc.

Frank E. Bell (T.M.), "B" Designer, Pacific Design and Development Company. Formerly, with United States Marine Corps.

HAINES-McCAULEY MERGER

John F. Haines (M.) was appointed Chief Engineer of McCauley Industrial Corporation last April upon the completion of a merger agreement between Haines Designed Products Corporation and McCauley Industrial. Mr. Haines, who holds an M.S. degree from Massachusetts Institute of Technology, was President and Chief Engineer of Haines Designed Products.



ELECTED BY FAIRCHILD

F. Eugene Newbold, Jr. (M.), who has been General Manager of Fairchild Engine & Airplane Corporation's Stratos Division since 1949, was recently elected a Vice-President of the corporation. Mr. Newbold joined Fairchild in 1940, following his graduation from Princeton University, and was assigned to the Engine Division. He became Manager of the Engine Division's engineering operations in 1948.

Martin Boxer (T.M.), Aerodynamicist, North American Aviation, Inc. Formerly, Test Engineer, Wright Aeronautical Division, Curtiss-Wright Corporation.

L. A. Bullard, Jr. (A.F.), Assistant to Assistant General Manager, Republic Aviation Corporation. Formerly, Chief of Flight Test, Chance Vought Aircraft Division, United Aircraft Corporation.

Frank J. Bundschuh (T.M.), now Draftsman "A," Lockheed Aircraft Corporation.

William E. Diener (T.M.), now Lieutenant, U.S.A.F., on Active Duty. Formerly, Student, Officer Candidate School.

William Clare Ennis (M.), now Chief Engineer, West Coast Electronics Company.

Edward E. Foster (A.F.), Executive Engineer, Development Division, Cornell Aeronautical Laboratory, Inc. Formerly, Head, Materials and Operation, Fairchild Guided Missiles Division, Fairchild Engine and Airplane Corporation.

David S. Goldstein (T.M.), Junior Aeronautical Engineer, Cornell Aeronautical Laboratory, Inc. Formerly, Junior Engineer "B," Preliminary Design Group, Boeing Airplane Company.

Jerry Grey (T.M.), Aeronautical Engineering Department, Princeton University. Formerly, Student and Technical Assistant, California Institute of Technology.

Second Lieutenant Paul C. Griep, U.S.A.F. (T.M.), now Pilot, 68th Fighter-Interceptor Squadron, A.P.O. 929, c/o P.M., San Francisco.

Randolph Hawthorne (A.M.), Managing Editor, *Aviation Age*. Formerly, Assistant Editor, *Aviation Age*.

(*I.A.S. News continued on page 57*)

The Commission Recommends...

In its report to the President, "The Airport and Its Neighbors," the President's Airport Commission [James H. Doolittle, Chairman (*left*), J. C. Hunsaker (*center*), and Charles F. Horne (*right*)] had a number of things to suggest to the aeronautical engineering profession to help alleviate noise and hazards at airports. The following paragraphs are quoted from the recommendations of the report. Following each recommendation is supporting material from the summary, also in the words of the report. (***See also pages 17 and 18.***)

REC. 13. Develop Cross-Wind Equipment

"Although modern transport aircraft can operate successfully in any but very strong cross-winds, the further development and use of cross-wind landing gear should be accelerated.

"A solution to many aspects of the airport problem is, in the opinion of the Commission, the early acceptance of the single or parallel runway design of airport with approaches over relatively clear areas. . . . The single or parallel runway airport has one shortcoming . . . difficulty of operation in strong cross-winds—but this is being overcome through pilot training techniques, the use of tricycle gears and the further development of special cross-wind landing gears.

"Too much emphasis has been placed on statistics of prevailing winds, including light and variable airs of little consequence in modern flying practice. As a result large sums still are being programmed unnecessarily for multiple intersecting runway airports, and too little consideration is being given to the hazard zones off the ends of these same runways. . . ."

REC. 15. Standard Runway Length

"For each category of airport a standard runway length has been established . . . for intercontinental or transcontinental airports, length of dominant runway should be 8,400 feet with possible expansion to 10,000 feet if later required.

"Most municipal authorities consulted by this Commission . . . urge that current standards of runway length be 'frozen' and remain in effect for a substantial period of time in order to protect their already large investment. They argue that airplane designers should apply the results of research and invention to the improvement of the safety performance and economy of their products within existing runway length limits.

". . . It seems to this Commission that major air terminals should eventually provide principal runways for the use of transcontinental or intercontinental airplanes . . . as indicated above. . . . A future change in the established standards for runway length should come only after compelling considerations. . . ."

REC. 17. Ground Noise Reduction

"Some excuse may be found for failure to have foreseen the rapid rate of aeronautical progress in designing airports in the past, but it is to be regretted that more consideration was not given to the comfort and welfare of people living on the ground in the vicinity of airports. . . . The public deserves a clear explanation of necessary airport procedures, accompanied by valid assurances that everything possible is being done to alleviate both noise and hazard . . . where operators are making a sincere effort to reduce engine run-up noise by controlled ground procedure and by the provision of proper acoustical treatment, and are avoiding take-offs over inhabited areas, reasonable people can

Editorial

be persuaded to tolerate some noise as a part of the cost of living in this age of technology.

". . . Aircraft designers and manufacturers must also assume a share of the noise alleviation task. So far, they have been concerned mainly with noise levels inside the airplane. They should also strive to minimize noise outside the airplane.

". . . Exhaust mufflers and slow-turning multi-blade propellers of large diameter have been applied successfully to quiet small airplanes. As aircraft become larger and faster, the power required to propel them and the resultant noise multiplies many-fold. Some noise reduction can be achieved, even in these large aircraft, by reduced propeller tip speed and by removing more energy from exhaust gases, but reducing their noise to comfortable proportions still presents a difficult problem.

"In the future, with wider use of high speed turbine-driven propellers or high thrust jet-propulsion, there will be a tendency for the volume of noise to increase beyond levels now experienced and for the character of the noise to become more objectionable. Research is now under way in these areas, but the problems are technically difficult and no effective solutions are in sight."

REC. 21. Minimize Test Flying Near Cities

"Production fly-away from aircraft factories under proper conditions is acceptable but all flying of experimental aircraft and test flying of production models near built-up areas should be reduced as far as possible.

". . . Recognizing the potential hazard involved, especially with the very fast jet types, some manufacturers have established test facilities on remote airports, and are making trial and shake-down flights away from congested areas. Whenever practicable this should be required. . . ."

REC. 24. More Flight Crew Training

"It is believed that through standardization and training, accidents due to pilot error can be reduced. There is, at the moment, a regrettable lack of uniformity of design and arrangement of transport aircraft cockpits. Not only is there variation between different types of aircraft, but also variations in the same type, depending on the ideas of individual airlines. A useful step in improving the training of pilots in emergency procedures would be the standardization and simplification of equipment in cockpits. Simplified emergency procedures naturally would follow. The pilot's job would be easier and safety would be increased.

"More training in emergency procedures should be required. Simulated emergency drills, in airplanes without passengers, should be conducted periodically. Such training flights should, of course, be conducted over uninhabited areas. A method of training flight crews without hazard is through the use of flight simulators. These are complicated devices duplicating the cockpit and flight deck of the airplane. The equipment and instrumentation are operated by an instructor to simulate various emergency conditions. The crew then deals with the situation as it would be in flight. Necessary practice is thus provided without risk. Since flight simulators are expensive and one is required for each type of aircraft, it may be necessary to purchase and use them on a cooperative basis."

REC. 25. Helicopters for Civilian Use

". . . Regional and city planning (involves) questions of interconnecting highway and air services and the integration of the air and ground traffic. (This) implies successful development of short-haul aircraft, possibly of the helicopter type.

"Concurrent with military helicopter development, interested Government agencies should encourage civilian helicopter design for inter-airport service and for short-haul use. Emphasis should be put on safety, liability and public toleration factors."

The High-Speed Propeller

GEORGE W. BRADY*
Curtiss-Wright Corporation

ABSTRACT

The aircraft propeller for use at transonic and high subsonic forward speeds is the result of aerodynamic and structural research carried out since World War II.

The application of tests of a number of different propeller configurations, including blades with sweepback, low aspect ratio, and low thickness ratio, to the design of transonic and supersonic propellers is discussed, and it is shown that good efficiency for the transonic propeller up to 0.85 Mach Number and for the supersonic propeller through the transonic region and well into the supersonic region can be obtained. Structural and allied problems are reviewed, and it is indicated that the desired aerodynamic characteristics can be obtained with a structurally satisfactory design.

Overall performance of a high output turboprop engine with both transonic and supersonic propellers is presented. Other important performance advantages of propeller propulsion such as high take-off thrust and reverse thrust for aerodynamic braking are outlined.

INTRODUCTION

THE AIRCRAFT PROPELLER, because of its high efficiency, has been used since the beginning of aviation as a means of transforming energy in the form of shaft power into thrust. Today, the propeller, in spite of new forms of aircraft propulsion, remains the most efficient means of utilizing the energy in fuel to propel an aircraft. To do this, new types of propellers have had to be developed for operation at transonic and supersonic speeds.

In addition to its primary purpose of providing thrust for propulsion, the propeller performs additional functions such as aerodynamic braking for landing, providing extra thrust for take-off, low fuel consumption for holding in traffic patterns, etc. These "plus" values are important in the practical operation of both military and commercial aircraft.

The propeller alone does not accomplish all this, since it must be driven by a prime mover. Up until the last few years, all such engines were of the reciprocating piston type. Maximum powers available in this type of power plant have steadily increased over the years until, at present, a maximum of about 4,000 b.hp. (brake horsepower) has been obtained. In the last 10 years, the gas-turbine engine with propeller drive has entered the picture with powers increasing to values of 5,000 b.hp. today and 10,000 or more possible. With these powers, airplane speeds have increased until cruising speeds only slightly less than the speed of sound and high speeds that are supersonic are attainable.

The piston engine with its years of development behind it is continuing into new and more efficient configurations, such as the turbocompound type that will give good performance up to about 400 m.p.h. At higher speeds and for applications where powers above those of available piston engines are required, the turboprop comes into the picture. Factors favoring the turbine engine include lighter weight, smaller size, greater increase in power with ram, negligible cooling drag, and ability to cruise at a higher precentage of its maximum power.

SUBSONIC PROPELLERS

Propeller development for piston engines has not reached its limit, but, in general, it is reasonable to say that it is unlikely that there will be any major changes in propeller configuration. Leaving out the small engines of below 500 hp., the piston-engine propeller will be of three or four blades, single rotation, except for a few six- or eight-blade dual- (contra-)

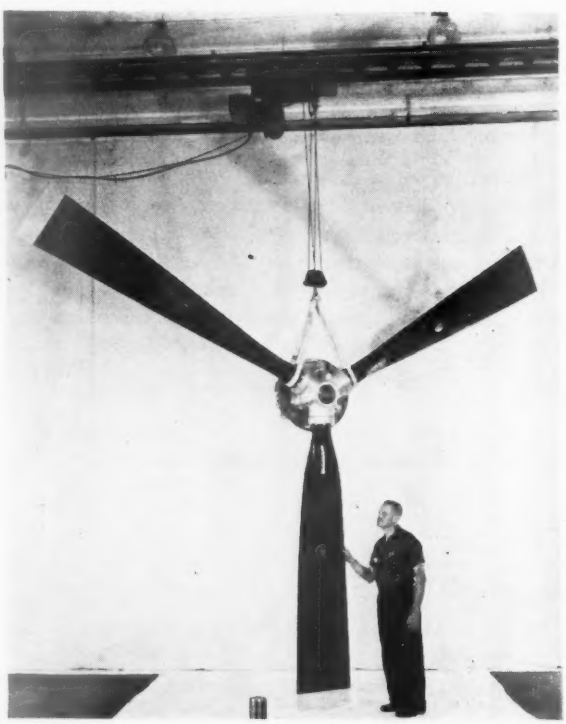


FIG. 1. Eighteen-foot diameter turbolectric propeller for 5,000–6,000 hp. turboprop engine.

Presented at the Flight Propulsion Session, Twentieth Annual Meeting, I.A.S., New York, January 28–31, February 1, 1952.

* Director of Engineering, Propeller Division.

rotation propellers, with metal blades of from 9 to 19 ft. in diameter. Controllable pitch of the blades is standard with constant speed, automatic synchronization, feathering, and reversing controls.

In the turbine engine, propellers for airplanes of the subsonic type will be relatively conventional and similar to the piston-engine propellers, except for the control that must be compatible with turbine characteristics. However, the higher powers and constant r.p.m. characteristics of the turbine will dictate some differences for optimum performance. For example, a typical piston-engined heavy transport-cargo airplane, such as the C-124A, will have a three-blade propeller of 16.5-ft. diameter for the R-4360 version and either a four-blade propeller of the same diameter or a slightly larger three-blade propeller for the turboprop version. The versatility of the propeller is also well-illustrated in the case of the Constellation series, in which a 15-ft. three-blade propeller configuration has been used with the various models having R-3350 engines rated from 2,200 hp. to the forthcoming compound type at 3,500 hp.

Development of subsonic propellers for turboprop engines may be illustrated by the three-blade 18-ft., single-rotation model shown on Fig. 1 for engines in the 5,000–6,000 shaft-horsepower range.

High-Speed Performance

Before proceeding to the detail discussion of operation at high speeds, it is of interest to recall that propellers and projectiles have been operating at supersonic speeds for a long time. In World War II, fighter propellers, for example, when operating at altitude at military power, had propeller tip speeds from 5 to 15 per cent above the speed of sound and provided extremely good efficiency. It was recognized, however, that, at the highest forward speeds of these airplanes, the propeller efficiency was below the maximum possible and that, for any higher speeds, substantial design changes would be required.

Test programs, which have been carried out in the years since World War II to determine the best solution to the high-speed propeller problem, have included unconventional configurations such as blades with sweepback, blades with low aspect ratio, and single-rotation eight-blade propellers. However, it has been determined that best results are obtained with a straight blade design having thin airfoil sections.

The reason for this is shown in Fig. 2, which gives a simplified blade element analysis for the case of operation at speeds of 300 and 600 m.p.h. at 35,000 ft. for two typical blade sections, one near the tip at 90 per cent radius and the other near the shank at 30 per cent radius. The section thicknesses used are 6 per cent and 20 per cent, respectively, and are typical of propellers used on present-day transport and military airplanes. At 300 m.p.h. the blade element efficiencies are good. However, at 600 m.p.h. the efficiency has

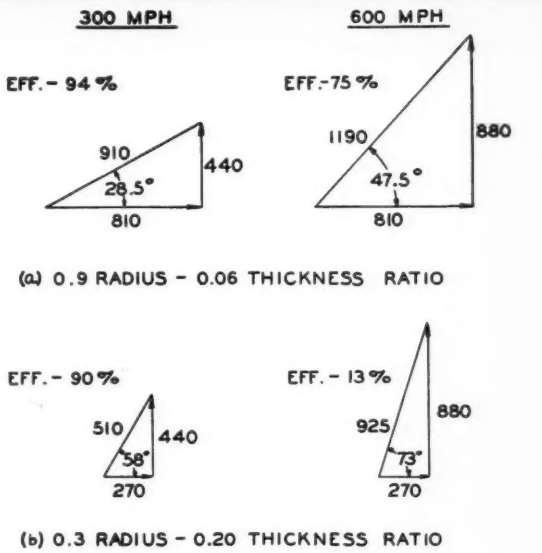


Fig. 2. Effect of increase in forward speed on blade element efficiency of propeller blade sections of typical subsonic propeller operating at 900 ft. per sec. nonhelical tip speed at 35,000-ft. altitude.

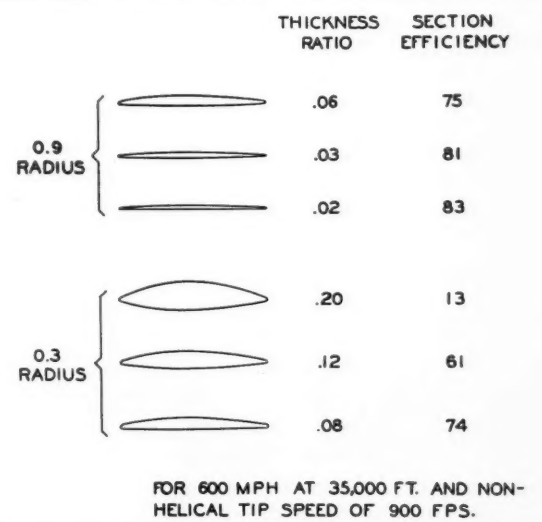


Fig. 3. Effect of reduction in thickness ratio on blade element efficiency of propeller blade sections.

dropped appreciably for the outboard station and substantially for the inboard one. Hence, the overall efficiency of the propeller of this type at high Mach Number will be low.

To overcome this effect, it is necessary to use sections that delay the drag rise as the speed of sound is approached or else which reduce the magnitude of the drag rise. Assuming it is possible to reduce the thickness ratio of each of the above sections to 3 per cent at the tip and 12 per cent inboard, the result shown on Fig. 3 is obtained. This shows a substantial improvement at the higher speeds but still has an appreciable drop for the inboard section. Neglecting structural considerations for a moment and reducing the shank thickness ratio to 8 per cent, a further efficiency in-

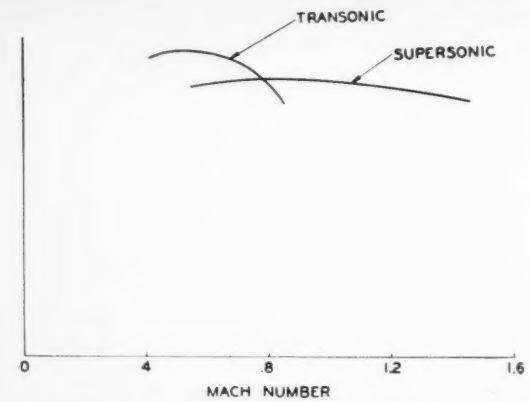


FIG. 4. Comparative efficiency at high speed of transonic and supersonic propellers.

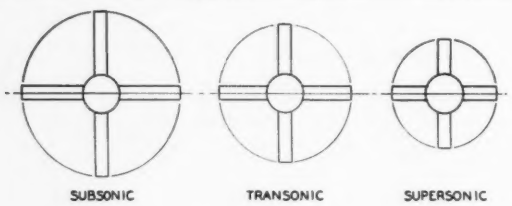


FIG. 5. Relative size of various types of propellers for same power.

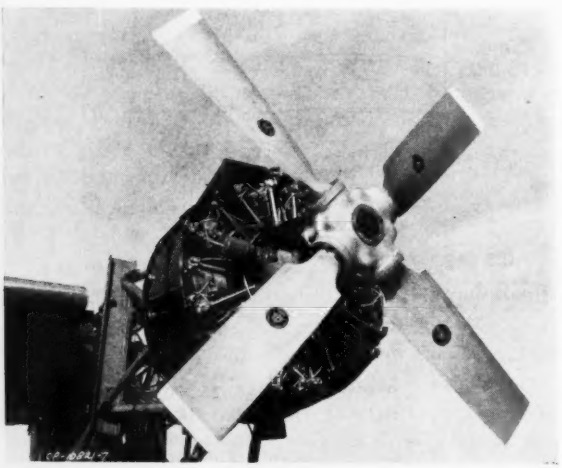


FIG. 6. Test supersonic propeller mounted on direct-drive engine.

crease results. However, this is still not as high as desired. This is due to another factor that has entered the picture—namely, excessively high blade angles that cause a drop in the section efficiency progressively as the wind angle (angle of the relative wind to the plane of rotation) increases above 45°. This leads us to one other way to improve propeller efficiency at high speed, that is to keep wind angle down to a value close to the peak point for the particular operating condition. This can be done for any fixed forward speed by increasing the rotational speed. For transonic forward speed this results in supersonic propeller-section speeds substantially all the way along the blade radius. For example, at 0.9 Mach Number forward speed, to keep the wind angle at the optimum of about 45° at the 0.75R., the rotational component must also be 0.9, and the resultant velocity will be 1.3. At the extreme tip the resultant velocity will be 1.5 Mach Number. If the individual section efficiencies under these conditions can be kept high, the overall propeller efficiency will be good.

It is expected that the "transonic" propeller—one which has thin sections to give high efficiencies at forward speeds in the high-subsonic or low-transonic region—will have an efficiency level above 80 per cent in the 0.75-0.85 Mach Number region with an advance ratio of about 3 and a tip speed of the order of 1.25. The take-off thrust of such a propeller will be 2.0 to 2.5 lbs. per hp.

The "supersonic" propeller—which may be defined as one having both thin sections and high r.p.m. so as to operate at low blade angles—will not have quite so good efficiency below 0.80 to 0.85 Mach Number as the transonic type but will be able to maintain its efficiency through the transonic and well into the supersonic region. Fig. 4 shows the relative efficiency of these two types of propellers. Fig. 5 shows their relative size.

From this discussion it is evident that modern developments in propellers provide excellent preformance well into the supersonic region.

As an example of how a supersonic propeller will look, Fig. 6 is presented showing a test propeller of this type. This particular photograph shows the propeller mounted on a piston engine that has had its reduction gear removed to permit driving the propeller at crankshaft speed.

In the discussion thus far only single-rotation propellers have been considered. Dual-rotation propellers are also an important type, and, in fact, have characteristics that make them preferable in certain applications. The dual-rotation propeller can operate at higher blade angles with less induced loss, because of the recovery of a considerable part of the rotational energy induced by the front propeller by the aft unit. Because of this the net torque of a dual-rotation installation is small, an advantage from the control standpoint for single-engined airplanes. From the performance standpoint, the dual-rotation propeller will extend the speed at which efficiencies of over 80 per cent can be obtained by from 0.02 to 0.05 Mach Number. Take-off and climb performance is also good. A further characteristic of the dual rotation propeller is the ability to absorb larger powers efficiently in a given diameter. It is probable that this characteristic will prove the most important as engine powers increase.

Where solidity obtainable with three or four blades is not adequate for a single-rotation propeller, it is possible to consider a greater number of blades. Design studies show that four blades are normally the maximum that can be readily used in a single row because of clearance problems between adjoining blades at the spinner surface. However, two rows of blades

in a tandem hub will permit six- or even eight-blade types of single rotation propellers to be used.

Structures

The structural problems for transonic and supersonic propellers are accentuated by the requirement of thinner sections. Increased knowledge of loads acting on propellers has made it possible, however, to achieve a satisfactory level of thinness while keeping stresses to reasonable values. At the end of World War II, propeller design was based primarily on designing the propeller to carry the loads due to rotational speed, engine torque, and forward (or reverse) thrust. An allowance was made for dynamic stresses, but this was generally done by using a conservative value, based on experience, for the allowable stresses.

However, in the postwar commercial and military installations, it was found that there were important stresses of other types, the principal ones being:

(1) 1xP—forced vibration due to inclined flow through the propeller disc. This is generally most severe in either high gross weight climb or low gross weight dive.

(2) 2xP—resonant vibration occurring in both the flapping and edgewise modes. Excited by uneven flow through the propeller disc both in flight and on the ground.

(3) 1.5xE, 2xE, 3.5xE, etc.—engine excited modes due to torque harmonics coinciding with a natural frequency of the propeller on the propeller-crankshaft system.

The symbol, 1xP, signifies that the number of cycles of excitation on each blade per one propeller (P) revolution is equal to one (1). Similarly the symbol, 2xP, means that two (2) excitation cycles occur in each propeller revolution. The terms, 1.5xE, 2xE, etc., refer to the gas and inertia torque harmonics excited by the reciprocating engine. For example, 2xE is that excitation occurring at twice engine speed.

Preliminary development work on thin (below 5 per cent thickness ratio) blades for transonic and supersonic propellers showed that another factor had to be taken into account. This was flutter, a factor that had been important in the early days of propellers but which had not been encountered in recent years. These factors have led to an intensive investigation of the dynamics of propeller structures and have brought forward methods that make it possible to predict with assurance the performance of advanced types of propellers.

The 1xP excitaton and flutter are probably the most important of the above factors in the design of transonic and supersonic propellers. The 2xP mode will generally be found relatively easy to handle, and the various engine orders will be either eliminated or greatly reduced with the turboprop engine.

Analyses and tests have shown that adequate structural strength to meet the various conditions of operation can be obtained with thickness ratios required to obtain good performance of transonic and supersonic propellers.

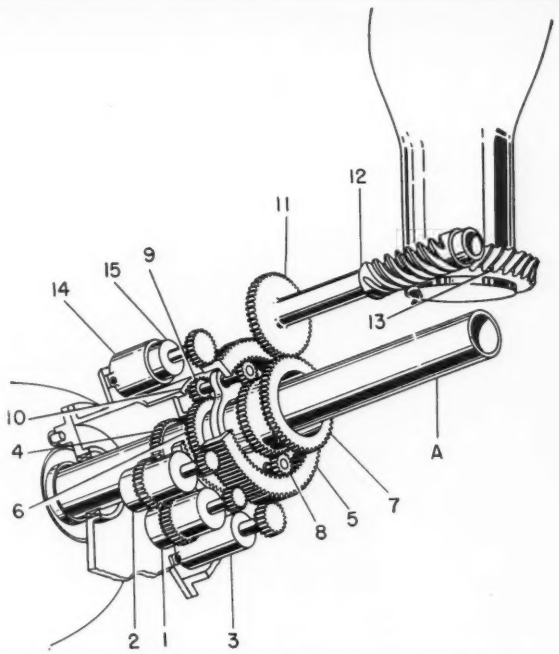


Fig. 7. Schematic drawing of pitch changing mechanism of turbolectric propeller.
(1) Increase pitch clutch; (2) decrease pitch clutch; (3) fixed pitch brake; (4) propeller shaft gear; (5) movable ring gear; (6) propeller shaft sun gear; (7) pitch change sun gear; (8) pitch change planet gear; (9) reaction planet gear; (10) fixed ring gear; (11) pitch change pinion gear; (12) blade worm gear; (13) blade gear; (14) electric motor (feathering); (15) electric motor clutch; (A) propeller shaft.

Design

The mechanical design of transonic and supersonic propellers is an extension of design principles established for conventional propellers. Blade retention loads, for example, increase from values of the order of 150,000 lbs. for a typical piston-engine propeller, to 300,000 lbs. for the transonic type, and to two or three times this amount for the supersonic case.

Pitch change loads are also higher, but recent developments in design have kept pace with requirements. If 20° per sec. is desired for rate of pitch change, a four-blade transonic propeller will require a pitch changing mechanism of about 30 hp. One type of mechanism for this purpose is the electrically actuated clutch type in which a pair of clutches, one for increase pitch and one for decrease, momentarily engage to the engine a worm and worm gear set mounted so as to rotate each blade about its axis. Thus engine power is used to change pitch. Variable rates of pitch change are obtained by a control system that energizes the proper clutch by a series of pulses which may be either of variable length or frequency. A schematic drawing depicting the general arrangement of one type of clutch-actuated propeller is shown in Fig. 7, and the arrangement of these elements on a full-scale propeller is shown

FIG. 8. Photograph of control mechanism of turbolectric propeller showing governor, housing for pitch changing clutches, pitch lock brake, and feather motor.

in Fig. 8. The requirements of the supersonic propeller in this regard are similar to the transonic.

Material for the blades of high-speed propellers will be steel—hollow for the transonic type and either solid or hollow depending on size for the supersonic. However, it would be desirable to be able to use a lighter alloy, and serious consideration will undoubtedly be given to use of one of the titanium alloys as a blade material.

OVERALL PERFORMANCE

The overall performance of a turboprop power plant depends on the combination of the efficiencies of the engine and of the propeller. The engine has a number of variables—component efficiency, compression ratio, gas temperature, and per cent of power to the propeller which are the factors of most importance to the performance of a specific engine.

Also, in the broad sense, turboprop engines should be considered with more complex cycles than the basic compressor-turbine models now available. These should include (a) regeneration cycles for lower fuel consumption and (b) reheating and a second turbine stage for increased power output. For the latter type, studies show that a power increase of the order of 30 per cent is possible, which is a factor of great importance in the application of propellers to high-speed aircraft.

Since the major advantages of propeller propulsion are fuel economy, high thrust for take-off, and reverse thrust for aerodynamic braking, it is of interest to determine some typical values for the kinds of propellers which have been discussed. The propeller efficiencies will be as given earlier in this paper. The turboprop engine performance is based on published data and analyses as to the effect of higher compression ratios and other factors to provide the best performance with realistic values for operating temperature, etc.

Applying transonic and supersonic propeller efficiencies, the performance on a thrust basis is as shown in Figs. 9 and 10.

It will be noted in these two figures mentioned that thrust at take-off speeds is good. For a thrust necessary to give a certain cruising speed in the 400 m.p.h. range, for example, the take-off thrust is more than twice as great. Specific fuel consumption in the take-off range is also low, a factor of considerable importance when considering practical take-off procedures. At high speeds in the transonic range, the specific fuel consumption on a horsepower basis is improving and on a thrust basis is increasing slowly. The absolute value of the specific fuel consumption at 0.8 Mach Number, for example, may be of the order of 0.4 or better on a horsepower basis and 0.65 in terms of thrust. In the case of the supersonic propeller, the performance through Mach Number of one remains good. For the engine with the reheat cycle, the specific fuel consumption is only about 10 per cent higher than that for the basic engine, which is a very favorable fuel consumption

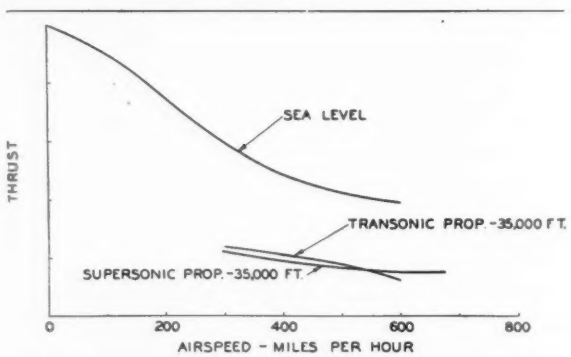


FIG. 9. Typical turboprop engine thrust at two altitudes.

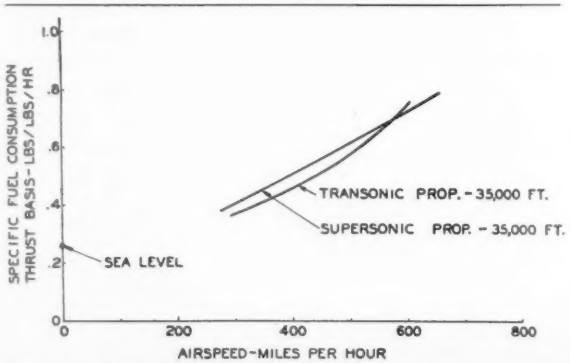


FIG. 10. Typical turboprop engine specific fuel consumption—thrust basis.

for a thrust increase of thirty per cent, particularly when comparing it with other forms of thrust augmentation.

Summary

Data have been presented to show that the high efficiency of the aircraft propeller, which has made it universally used in the subsonic-speed range, can be extended in practical designs through the transonic region and well into the supersonic. To do this, aerodynamic refinements have had to go hand in hand with structural developments, since the principal requirement for the higher speeds is thin sections.

Ability to obtain good propeller efficiencies at high speeds brings together high thrust and high economy. Together with the plus values of good take-off and reverse thrust for aerodynamic braking, the propeller-turbine combination has outstanding advantages to all aircraft where range, economy, and ability to operate under any weather and traffic conditions are important.

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Some Aspects of the Aircraft Noise Problem

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Introduction

The problem of noise reduction of aircraft has been of interest for many years but is becoming of greater concern because of the ever increasing number of people affected. Because of increases in noise levels, not only passengers, crews, and service personnel of airplanes but also larger groups of people working and living near airports and test facilities are affected to a greater degree. As a result of the interest in noise, the N.A.C.A., other agencies, and aircraft companies have been engaged for some time in studies relative to the noise problem in general. By way of example, reduction of noise reaching the ground from light airplanes was considered by the N.A.C.A. a few years ago in connection with the airport noise problem. Although it was demonstrated then that a solution to this particular problem was technically feasible, a satisfactory solution to the more significant and complex problem of quieting the larger and more powerful transport-type aircraft was not available. Subsequent developments resulting in more powerful propulsion systems for military and commercial use may aggravate the already serious noise problems. Consequently, the N.A.C.A. is continuing its basic noise research in an attempt to define present and future noise problems and to explore the possibilities of their solution.

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* Aeronautical Research Scientist.

† Physicist.

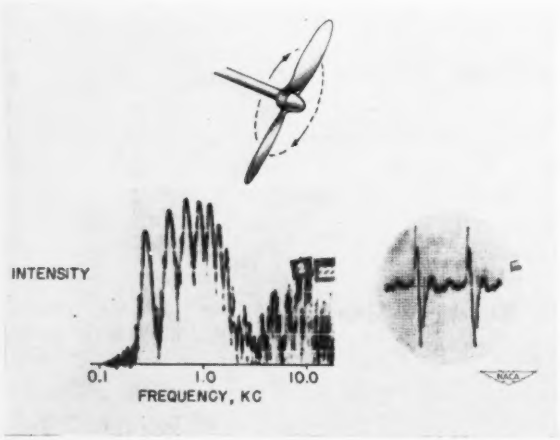

Fig. 1. Noise generated by a constant force that, as a function of time, varies in distance to the observer.

The present paper considers three aspects of the aircraft noise problem. It first gives results of past and current N.A.C.A. research with regard to the physical characteristics of the noise from various noise sources such as propellers and jets. It then briefly discusses the results of the work of other organizations with regard to two additional aspects of the problem—namely, the effects of noise on speech and hearing and ways of protection from noise.

Physical Characteristics of Aircraft Noise

In discussing the physical aspects of the problem, we will be concerned with the sources of the noise, their spectrums and intensity levels, and how the noise varies as a function of various parameters that affect it.

Noise from Propellers

One basic type of noise is generated by propellers and is illustrated in Fig. 1. The rotational noise, which is the main component of propeller noise, is generated by a constant aerodynamic force on the blade which, as a function of time, varies in distance to the observer. There is a tendency for the largest sound pressures to appear near the plane of rotation where this distance variation is greatest. A typical supersonic-type propeller-noise spectrum[1] is shown on the figure where intensity appears on the vertical scale as a function of frequency on the horizontal scale. The noise consists primarily of a few frequencies of constant amplitude which are harmonically related to the blade passage frequency. It is significant that at supersonic tip speeds some of the higher harmonics are more intense than the fundamental, with the result that the characteristic wave form is sharply peaked, as shown by the typical pressure time history record shown on the figure. At subsonic tip speeds the spectrums differ from the one shown here in that the higher harmonics are generally less intense than the fundamental. Noise frequencies from either type of propeller are most intense below approximately 1,500 cycles per sec.

Some of the parameters significant in the generation of propeller noise are illustrated in Fig. 2. This material is a composite of the results of a general N.A.C.A. propeller-noise research program reported in references 1–8. Sound intensity in decibels is shown as a function

of rotational tip Mach Number for both a two-blade and a six-blade propeller for constant power input. It can be seen that a decrease in sound intensity can be achieved by using more propeller blades; however, the decrease obtainable is greater at the lower tip speeds than at the higher ones. For both propellers, the tip Mach Number is a significant parameter in the subsonic range, while, in the supersonic range, the sound intensity is essentially independent of the tip Mach Number. At subsonic tip Mach Numbers, large sound reductions can be obtained by increasing the number of blades and reducing the tip Mach Number. At supersonic tip Mach Numbers, a relatively small benefit would result from this technique. Some preliminary tests have shown that blade plan form, which apparently is not significant at subsonic tip Mach Numbers, may be significant in the supersonic range. The wider blades may cause some reduction in intensities, particularly for the higher harmonics.

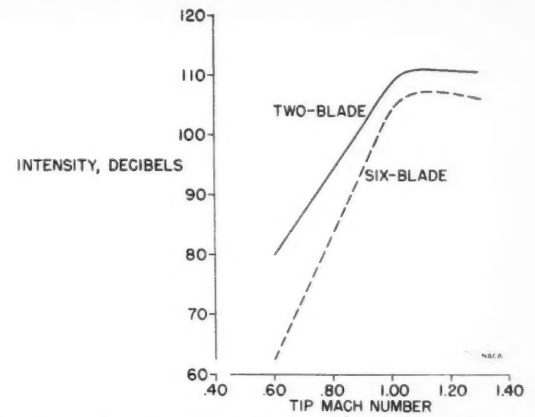

FIG. 2. Effects of tip Mach Number and number of blades on the noise produced by single rotation propellers at constant power input.

Noise from a Pulsing Flow

Another basic type of aircraft noise source, pulsing flow, is illustrated schematically in Fig. 3. This noise source is most generally associated with pulse-jet engines, since they are designed to operate in a cyclic manner. The exhaust gases are expelled periodically at a frequency that is a function of the operating temperature and the volume of the combustion chamber. The noise spectrum associated with this type of source contains only a few discrete frequencies with the fundamental or firing frequency being the most intense. The associated wave form is nearly sinusoidal and shows the predominance of the fundamental frequency.

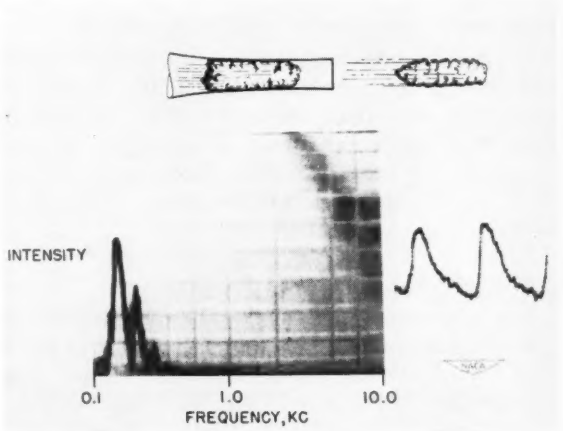

FIG. 3. Noise generated by a pulsing flow.

Even though this predominantly low-frequency spectrum is usually associated with pulse-jet operation, similar results have been obtained for ram-jets and turbojet units with afterburner operation. Thus it is believed that the noise spectrums generated by pulsing flow phenomena are closely related to those associated with conditions of rough burning and/or resonance which may occur during operation of continuous-type jet engines. Little information is available concerning these latter phenomena, since they are avoided in practice whenever possible because of intense noise and vibration.

Another pulsing flow phenomenon is illustrated in Fig. 4, which shows schematically the composition of a typical exhaust spectrum from a 200-hp. reciprocating engine. Again, the fundamental firing frequency is the most intense, and the other frequencies present tend to be lower in amplitude. This spectrum is more complex than that from the pulse-jet, since it contains some subharmonics, which are believed to result from dissimilarities in the manifold system, and some high-frequency components of an aerodynamic origin. Judging from the quality of the spectrum, the task of reducing the overall noise is apparently one of reducing the low-frequency components since they are of great strength. However, there is some difference of opinion

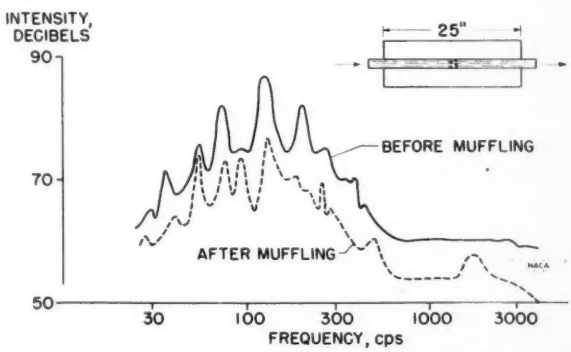

FIG. 4. Exhaust noise spectrum for a small reciprocating engine before and after muffling.

as to which frequencies need to be reduced, since some observers feel that the higher order ones are most objectionable. For any given reciprocating engine we can look to the exhaust muffler as a means of reducing the noise. A simple muffler is shown schematically in the figure, and its effectiveness is shown as the space between the two curves. This particular design is capable of providing some noise reduction

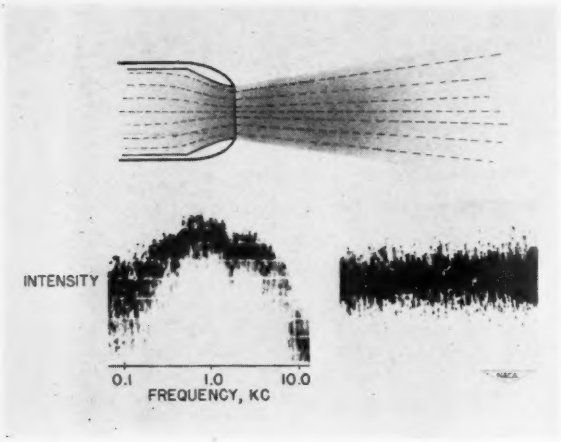

FIG. 5. Noise generated by jet mixing and turbulence.

throughout the spectrum and provides an overall noise reduction in this case of approximately 8 db.

The basic principles of muffler design are well known, and those that apply specifically to the muffling of small aircraft engines are indicated in reference 9. For larger engines, additional research and development work are needed to produce satisfactory designs from the standpoint of noise reduction, weight, and safety.

Noise from Jets

The next noise source that will be considered is the mixing region of a jet, as shown schematically in Fig. 5 along with a typical spectrum and wave form. The mixing region of the jet is of interest because it is the main source of noise from the turbojet engine. The mechanism of this type of noise generation is not well understood, but experiments have shown that a smooth flowing jet of air issuing to the atmosphere is an intense noise source. This noise is apparently associated with turbulence, and a typical spectrum contains nearly all frequencies from the subaudible to the ultrasonic range.[10] Since so many frequencies are present and in random phase, the resulting wave form presents a hashy picture as a function of time in contrast to the steady characteristic wave form of the propeller in Fig. 1. The distribution of energy in the sound spectrum of jets was found to be a function of the jet size and the observer's position. The results obtained with any specific analyzing equipment will also be affected by the bandwidth of the analyzer. For jet engines in current use, the peak intensities will probably occur at 1,500 cycles per sec. or below.

From current tests, it has been found that turbojet engines are closely related to simple air jets with regard to their noise generation. It was also found that jet noise increased in intensity as the jet velocity, density, and turbulence increased. The predominant parameter affecting the intensity is the jet velocity, and this effect is shown in Fig. 6. Sound pressure in decibels is shown as a function of the exit gas velocity. The sound pressures are seen to be an exponential function of the exit gas velocity, with the exponent being slightly larger than 3. Thus, if the velocity were varied by a factor of 2, the sound pressures would be varied by about 20 db. This figure indicates that an increase in the exit gas temperature with the higher associated jet velocities will lead to higher noise levels.

The data of Fig. 7, where overall intensity levels are shown as a function of the observer's azimuth angle, will allow a comparison of the noise generated by a turbojet engine with and without afterburner. Both sets of data were recorded at the same distance from the source and are adjusted to the same thrust rating. It can be seen that the directional properties are approximately the same but that the noise levels associated with the afterburner are higher at all azimuth angles. This increase is due in part to the higher exit velocities of the afterburner.

Noise from Turbopropeller Units

Since there is considerable interest in the turbopropeller unit, some estimates of the noise have been

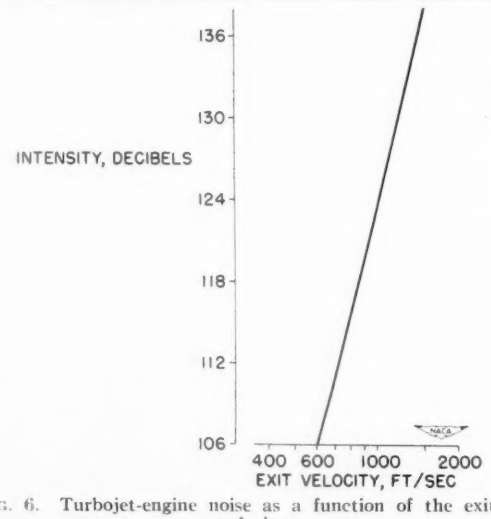

FIG. 6. Turbojet-engine noise as a function of the exit gas velocity.

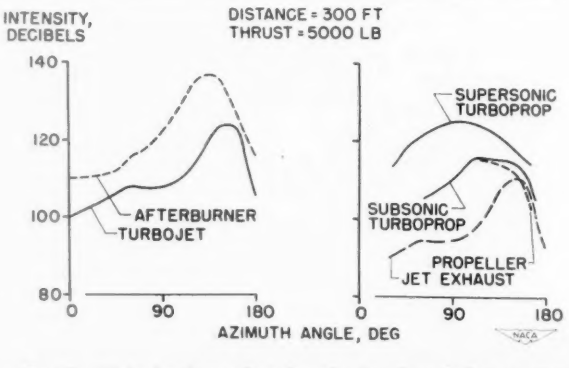

FIG. 7. Noise levels as a function of azimuth angle for a turbojet with and without afterburner and, as estimated, for two different turbopropeller units.

made by the use of results from current research on propellers and jets. The right-hand side of Fig. 7 shows a comparison of the estimated noise levels for two different turbopropeller units and provides opportunity to compare the respective noise levels with those for the jets of Fig. 7. The distance and thrust ratings are adjusted to the same values for all units of Fig. 7. In the case of the turbopropeller unit at take-off, the propeller is assumed to provide 90 per cent of the thrust and the jet exhaust 10 per cent. The subsonic turbopropeller (tip Mach Number = 0.90) curve has been estimated from the two dashed curves shown on the figure which show, respectively, the contributions of the jet exhaust and the propeller to the overall noise. It can be seen that, at the given conditions, the propeller is the major contributor, although at some azimuth angles the jet exhaust noise may be in the same order of magnitude. In the case where a supersonic-type propeller is used, the propeller is clearly the dominant noise source at all azimuth angles.

Comparison of the Maximum Intensities from Various Sources

The data of Fig. 7 will allow a comparison of the noise from propulsive devices that are being considered for use by both the commercial and military organizations. For a further comparison of the maximum intensity levels that are generated by these and other propulsive devices, the data of Fig. 8 are of interest. Data in each case have been adjusted to correspond to a distance of 300 ft. and to a thrust rating of 5,000 lbs.

Several observations may be made from the figure. The best obtainable estimate of the exhaust noise for a reciprocating engine alone is somewhat lower than the propeller noise, thus indicating that reduction of the exhaust noise without also reducing propeller noise will result in a relatively small noise reduction. If substantial reductions were made in the noise from present-day propeller-driven aircraft, it would be necessary to reduce both the propeller and exhaust noise.

The noise levels associated with such high performance units as the supersonic-type propeller, the afterburner, and the rocket engine are higher than for our present-day propulsive devices. Consequently, their use will aggravate the noise problem in neighborhoods where there are low-flying airplanes and ground testing of engines.

Some Effects of Noise on Speech and Hearing

Because of the large number of people being exposed to aircraft noise, it is of interest to evaluate some of its effects. Detailed consideration of this aspect of the problem is outside the scope of the present paper; hence, only a brief discussion of two related phenomena will be given.

Masking of Speech

It is generally recognized that noise is capable of interrupting conversational speech. Probably people experience this noise phenomenon more than any other. For people living near an airport, this constitutes a nuisance, whereas in vital communications it may be a great hazard. This phenomenon is called masking, and the amount by which the hearing threshold is raised for each frequency is a measure of the masking. The masking action of a 400 cycle per sec. pure tone of 70 db. intensity is illustrated in Fig. 9 as a function of frequency.[11] It can be seen that a relatively small amount of masking is produced at frequencies below the masking frequency, whereas a relatively large amount of masking occurs at frequencies above the masking frequency. The most detrimental effects of masking occur at frequencies nearly coincident with, and slightly above, the masking frequency. The noise frequencies below the speech range even at relatively low intensities will have some masking action on speech. Noise frequencies above the speech range will have little or no masking effect.

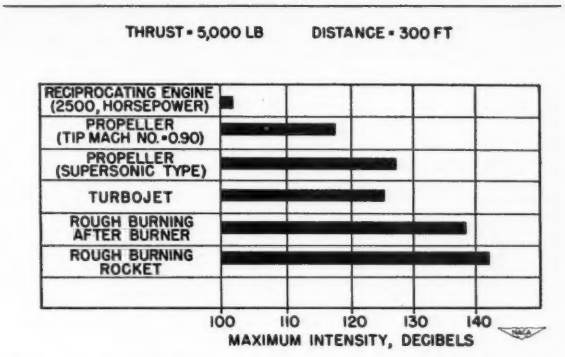

FIG. 8. Comparison of the maximum noise levels generated by various propulsive units.

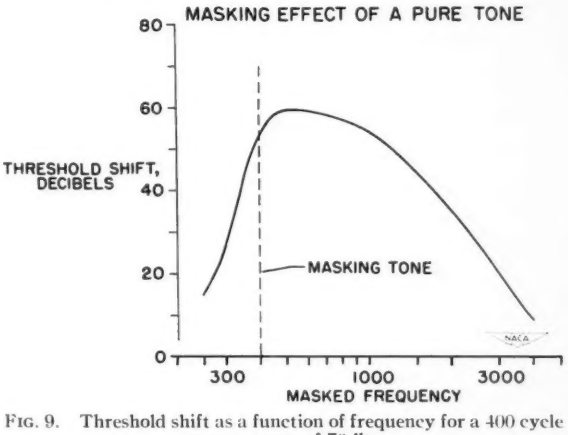

FIG. 9. Threshold shift as a function of frequency for a 400 cycle per sec. tone of 70 lb.

Hearing Losses

Hearing losses will, in general, be of concern only to those people who are working close to the noise source. The nature and amount of hearing loss produced are functions of the intensity of the noise, its frequency, and the duration of exposure. A given hearing loss may be incurred by exposure to an intense noise of short dura-

tion or by a less intense noise of longer duration. Fig. 10 illustrates the temporary hearing loss for an observer after a short exposure to a rather intense jet-engine-noise spectrum.[10] In this case it may be seen that the greatest hearing losses occurred in the range of speech frequencies from 500–2,000 cycles per sec. In general, the greatest effects occur at the predominant noise frequency or above, as in the case of masking in Fig. 9. We can thus estimate that the jet-noise spectrum that caused this hearing loss had intense components below 1,000 cycles per sec. Most hearing losses are temporary and become permanent only after repeated exposure before recovery is complete.

Protection from Noise

The most desirable method of protection from noise is to reduce it to an acceptable level at the source. Because of performance considerations and the high levels inherent in aircraft propulsion systems, this condition is difficult to realize, and it is of interest to explore other means of protection.

Spatial Isolation

Since relief from noise is obtainable by merely increasing the distance between the observer and the noise source, it is of interest to evaluate this effect of distance on the noise from the various aircraft noise sources. Noise reduction as a function of distance is shown in Fig. 11 for the frequencies of 1,000, 3,000, and 10,000 cycles per sec.[12] The solid line represents the noise reduction due to the normal spreading of a sound wave according to the inverse square law. It may be seen that for frequencies in the order of 1,000 cycles per sec. or below there is little additional noise reduction due to atmospheric effects, while at higher frequencies the atmospheric losses may be large. Since most aircraft noise spectrums have relatively large components in the frequency range below 1,500 cycles per sec., the solid line of Fig. 11 will essentially describe the intensity as a function of distance except for great distances.

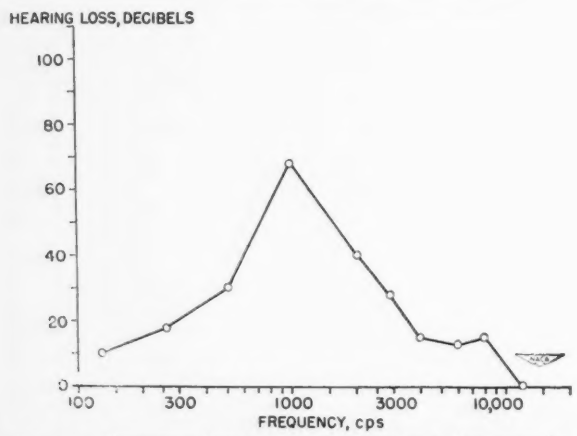

Fig. 10. Temporary hearing loss as a function of frequency following a 10-min. exposure to jet-engine noise of 146-db.

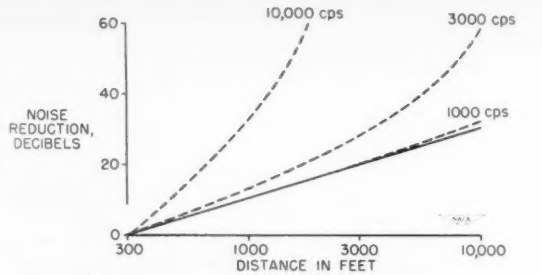

Fig. 11. Noise reduction as a function of distance from the source.

The data of Fig. 11 are for conditions of sound propagation for clear areas such as over an airport runway and from an airplane flying overhead. In the case of terrain with obstructions such as high grass, shrubbery, trees, etc., the average attenuation is somewhat greater than indicated in the figure.

Soundproofing

In instances where groups of people are required to be near noise sources for long periods of time, soundproofing may be used as a means of protection. This technique requires the use of a structure, and two physical phenomena involved are the sound transmission and sound absorption qualities of the structure. It is shown in reference 13 that in order to achieve large noise reductions it is necessary to have large transmission losses and at least nominal absorption losses. Since the transmission loss is the most important parameter in connection with large noise reductions, it is of interest to see how it is affected by the noise frequency and the panel density.

Fig. 12 shows the theoretical transmission loss in decibels as a function of frequency in cycles per second for sound passing through three homogeneous panels differing in weight. Although some variations in the data exist, the trends of Fig. 12 are verified by experiment.[14] It can be seen, in general, that the larger losses occur at the higher frequencies. In order to increase the transmission losses at the lower frequencies, the weight of the structure must be increased. The solid line may be considered representative of airplane fuselages, while the line of small dashes is more in the order of test cell construction. Since perfect absorption is assumed, these noise reductions are larger than would be obtained in practice. The fact that noise reductions are more difficult to obtain at the lower frequencies is significant, since it has been shown that most aircraft noise spectrums contain relatively intense low-frequency components.

Personal Protection

The most widely used type of personal protection for persons working close to the noise source is the ear plug. This device in connection with the standard Air Force helmet provides substantial noise reductions over a wide range of frequencies[15] and is useful to test-cell

personnel and to persons working near ground runups of engines. The effectiveness of each of these devices when used separately and in combination under optimum conditions is illustrated in Fig. 13. The noise attenuation in decibels is plotted as a function of frequency in cycles per second. The attenuation available for a combination may vary from approximately 30–80 db., depending on the noise frequency, and for the speech range averages approximately 50 db.

The difference in levels between air and bone conduction of sound is approximately 50 db. Equipment designed for protection against bone conduction would be cumbersome and, hence, of limited use. The protection provided by a well-fitted ear plug and helmet combination may therefore represent the practical limit of protection for the ear. This combination will provide adequate protection for short exposures to relatively high intensity levels or for long-term exposures to nominal intensity levels.

Concluding Remarks

In conclusion, three phases of the aircraft noise problem have been discussed. The physical aspects of the n ise were considered in some detail, and the effects of noise on speech and hearing and some ways of protection from noise were then discussed briefly. Conclusions that can be drawn from these and other related studies indicate that no easy and inexpensive solution to the aircraft noise problem is presently available. Reductions of noise at the source are possible in some cases as for the propeller and reciprocating engine, but only if some performance penalty is acceptable. The problem of providing adequate protection is in many cases expensive and is complicated by the intense low-frequency content of the noise from most aircraft noise sources.

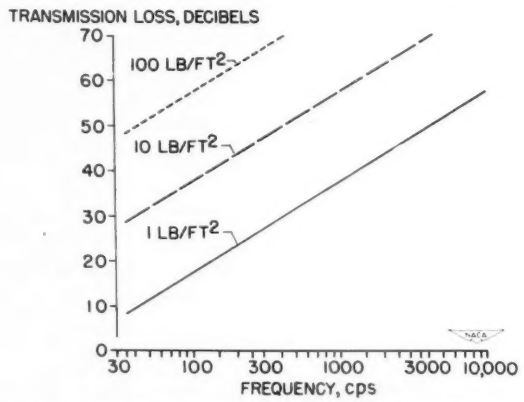

Fig. 12. Theoretical transmission loss as a function of frequency for three homogeneous panels varying in surface density.

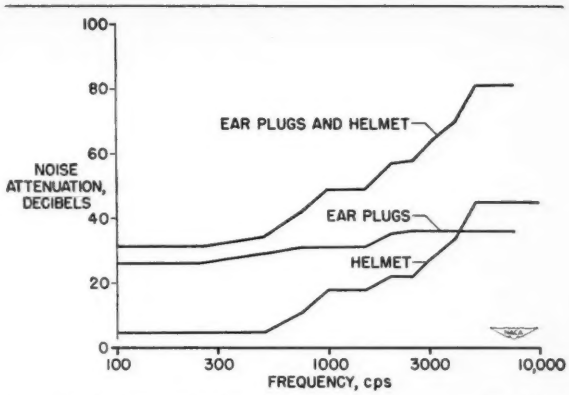

Fig. 13. Noise attenuation as a function of frequency for V-51R ear plugs and standard U.S. Air Force helmet.

References

[1] Hubbard, Harvey H., and Lassiter, Leslie W., *Sound from a Two-Blade Propeller at Supersonic Tip Speeds*, N.A.C.A. R.M. No. L51C27, May 8, 1951.

[2] Hicks, Chester W., and Hubbard, Harvey H., *Comparison of the Sound Emission from Two-Blade, Four-Blade, and Seven-Blade Propellers*, N.A.C.A. T.N. No. 1354, July, 1947.

[3] Hubbard, Harvey H., *Sound from Dual Rotation and Multiple Single Rotation Propellers*, N.A.C.A. T.N. No. 1654, July, 1948.

[4] Hubbard, Harvey H., and Regier, Arthur A., *Free Space Oscillating Pressures near the Tips of Rotating Propellers*, N.A.C.A. Report No. 996, 1950.

[5] Hubbard, Harvey H., and Regier, Arthur A., *Propeller-Loudness Charts for Light Airplanes*, N.A.C.A. T.N. No. 1358, July, 1947.

[6] Vogeley, A. W., *Sound-Level Measurements of a Light Airplane Modified To Reduce Noise Reaching the Ground*, N.A.C.A. T.N. No. 1647, July, 1948.

[7] Theodorsen, Theodore, and Regier, Arthur A., *The Problem of Noise Reduction with Reference to Light Airplanes*, N.A.C.A. T.N. No. 1145, August, 1946.

[8] Beranek, Leo L., Elwell, Fred S., Roberts, John P., and Taylor, C. Fayette, *Experiments in External Noise Reduction of Light Airplanes*, N.A.C.A. T.N. No. 2079, May, 1950.

[9] Davis, Don D., Jr., and Czarnecki, K. R., *Dynamometer Stand Investigation of a Group of Mufflers*, N.A.C.A. T.N. No. 1838, March, 1949.

[10] Parrack, H. O., *Aircraft Noise and Noise Suppression Facilities—an Evaluation*, presented to the Joint Conference A.M.C.-A.I.A., Los Angeles, April 11–12, 1950.

[11] Davis, A. H., *Modern Acoustics*, p. 246; G. Bell and Sons Ltd., London, 1934.

[12] Regier, Arthur A., *Effect of Distance on Airplane Noise*, N.A.C.A. T.N. No. 1353, June, 1947.

[13] London, Albert, *Principles, Practice, and Progress of Noise Reduction in Airplanes*, N.A.C.A. T.N. No. 748, January, 1940.

[14] Nichols, R. H., Jr., Sleeper, H. P., Jr., Wallace, R. L., Jr., and Ericson, H. L., *Acoustical Materials and Acoustical Treatments for Aircraft*, Journal Acous. Society of America, Vol. 19, No. 3, p. 428, May, 1947.

[15] Eldredge, Donald H., Jr., and Parrack, H. O., *Sound Problems in the Air Force*, United States Armed Forces Medical Journal, Vol. 1, p. 449, April, 1950.

Safety in Design

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Introduction

In the troubled times that beset the world today, it is imperative that the forces that were created to protect our Nation and the other peace-loving nations of the world be held in readiness to strike at the peak of their potential operational effectiveness. Note the phrase "potential operational effectiveness." The potential of the greatest air force in the world can be greatly diminished by factors that either (1) destroy trained crews and their aircraft before they even enter combat or (2) keep aircraft grounded while expensive modifications are retrofitted on them. Combat readiness must be maintained at a high efficiency in order that the objectives of our Air Force can be fulfilled.

The reduction in the rate of aircraft accidents is one factor that can help keep our Air Force up to its planned peak striking power. Aircraft accidents have always been a matter of concern to the U.S.A.F. Early in 1950, in order to better pursue an aggressive and positive accident prevention program, the Air Force established, in its Inspector General structure, an organization under Major Gen. Victor E. Bertrandias. This organization is composed of three Directorates—Procurement Inspection, Technical Inspection, and Flight Safety Research. These Directorates are headed by Brig. Gen. Clarence P. Kane, Thomas O. Hardin, and Richard J. O'Keefe, respectively.

Procurement Inspection

The mission of the Directorate of Procurement Inspection, in general, is to keep the Chief informed as to whether maximum return for each dollar expended is being effected in terms of efficient, economical, and expeditious procurement of the required quality and quantity of aircraft, components, and supporting equipment. The material to fulfill this broad objective is obtained by surveys and inspections encompassing all functions or activities having an impact upon the expenditure of the procurement dollars regardless of level or command.

Technical Inspection

The mission of the Directorate of Technical Inspection is to inspect and evaluate maintenance and technical inspection systems and techniques throughout the Air Force, and to recommend modernized and standardized systems of maintenance and technical inspection. The objective of the Directorate is to bring to the attention of commanders deficiencies that are hindering the most economical and effective use of maintenance personnel and equipment and, thus, to improve the quality of aircraft maintenance and to increase operational efficiency throughout the Air Force.

Flight Safety Research

The mission of the Directorate of Flight Safety Research is to contribute to the establishment of peak operational effectiveness in our Air Force through the prevention of aircraft accidents. This is to be accomplished by the formulation and development of policies, standards, and procedures covering an Air Force-wide accident prevention program. In order to fulfill adequately this important assignment, four main divisions were created within the structure of the Directorate of Flight Safety Research. These divisions are: (1) the Records and Statistics Division, (2) the Safety Education Division, (3) the Medical Safety Division, and (4) the Investigation and Safety Engineering Division.

The Records and Statistics Division, as the title clearly implies, maintains up-to-date records of all aircraft accident reports dating from 1908 and individual flying time for rated personnel of the entire U.S.A.F. Through the use of IBM machines, pertinent information on each U.S.A.F. aircraft accident is maintained in an easy, accessible form. This Division prepares statistical studies on various subjects, such as pilot proficiency, age versus accidents, trends and accident cause factors, cost account of aircraft accidents, etc.

The Safety Education Division determines and attempts to satisfy the educational needs of the U.S.A.F. in connection with the reduction of aircraft accidents. This Division produces such publications as *Flying Safety Magazine*, *The Aircraft Accident and Maintenance Review*, numerous posters, and special bulletins.

The *Flying Safety Magazine* is a general interest publication for all levels of Air Force personnel. It contains feature articles on accident prevention, cartoons, guest editorials, and stories by prominent Air Force leaders.

The *Aircraft Accident and Maintenance Review* is designed to furnish commanders, pilots, and maintenance men with the more technical side of accident prevention. It furnishes descriptions of accidents of

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interest, maintenance tips, and notes from manufacturers which pertain to Air Force equipment and operations. This publication serves as a medium for dissemination of information both on accident prevention and technical inspection.

The "Rex Riley" poster is employed to portray graphically a specific type of accident or incident which is causing current difficulty. It is a sequence type of cartoon designed to appeal to personnel who ordinarily would not be inclined to read other, more serious publications on accident prevention.

"Crash and Consequences" is another quick reading poster which describes specific accidents and their causes in order to provide preventive lessons for pilots and crew members.

The Medical Safety Division determines psychological and physical factors that cause individuals to have accidents. This Division also compiles and evaluates data on injuries and deaths with the ultimate objective of recommending improvements in equipment and structures in the interest of human efficiency and safety.

The Investigation and Safety Engineering Division analyzes all Air Force accidents and also conducts investigations of those accidents that are of particular interest or would affect the overall operation of the Air Force. In general, the accidents of particular interest are those involving new equipment or new type aircraft. These investigations require utilization of all available talent in tracing down possible factors that may have caused or contributed to the accident. Engineering consultants of wide experience with a background of accident investigation have been employed within the past year in the Directorate to aid the Air Force personnel in these investigations. In addition, aid is very often supplied upon request from the various engine, aircraft, and accessory manufacturers, as well as other Government and civilian research agencies. Arrangements have been made with a number of our major engine, propeller, and aircraft manufacturers to assign representatives to the Directorate on a temporary basis.

As a result of studies and investigations, recommendations have been made pertaining to improvements in the aircraft, power plant, accessory units, standardization of instruments and controls, lifesaving equipment, and many other items concerning safety.

Several of the findings of this Directorate during the past year will be presented. However, the discussion will be of those cases that pertain to faulty design, inadequate analysis of specific functional problems, and/or lack of safety consciousness—factors that have either been the primary cause of aircraft accidents or the subject for corrective action due to their potential hazard. It must be recognized that for security reasons and to avoid possible embarrassment to manufacturers, no particular model or designation of type will be mentioned.

Case Studies

Case No. 1.—On a gunnery run recently performed by one of our latest aircraft, a malfunctioning of the electrical equipment was noticed, as well as a severe vibration in the aircraft. Included in the electrical failure was complete loss of the a.c. power at the Engineer's panel. This caused a loss of electrical power to the turbocontrol, spark-control, and mixture-control circuits which placed a limitation on the maximum power that could be safely drawn from the engines, since these controls can only be positioned electrically. The aircraft had lost one of its engines right after take-off and also a second engine as a result of mechanical trouble during the gunnery run. In order to maintain altitude, attempts were made by the flight crew to draw power in excess of the maximum safe limit which resulted in progressive detonation failures of several of the engines until a crash was unavoidable. In the crash, the aircraft was completely destroyed.

Since a malfunctioning of the electrical system became evident immediately following the gunnery runs and since the vibration of the aircraft was judged the most severe ever experienced by several of the crew, it appeared that whatever caused the electrical malfunctioning and severe vibrations was associated with the firing of the guns.

With this hypothesis in mind, inspections of the retractable gun turrets of similar model aircraft were made. The upper aft turrets were extended and retracted several times. This operation is performed by an electric motor that cranks the lower member of the nutcracker upward for extension and downward for retraction. For the extension, the two arms of the nutcracker are rotated into place until the axis is positioned just beyond dead center. When the mating surfaces of the lower end of the upper arm and the upper end of the lower arm come into intimate bearing contact, a limit switch is actuated which shuts off the current to the motor. Examination of this switch revealed that it was of the ordinary type, easily subjected to malfunctioning due to shock, temperature, and moisture. In addition, the switch was so placed on the nutcracker legs that, unintentionally, it formed a natural ledge for support of the foot of flight personnel in climbing up or down from the gun turret.

A malfunctioning of this switch, wherein the operation occurs too soon, would cut off the actuating motor before the two mating surfaces on the ends of the actuating arms of the gun turret could come into intimate contact. With the ends of the nutcracker thus open, it is obvious that a high acceleration and resultant shock would result upon firing of the guns.

In order to substantiate this, gunnery tests were performed in the air with the nutcrackers in the locked position and also with the mating surfaces of the legs slightly open. During the "in-flight" gunnery test the rear turrets were first fired with the nutcracker in the locked and rigid position. The vibrations were judged

heavy but usual by men with gunnery experience on this type of aircraft. The legs were then opened approximately $^1/_{32}$ in. and only 2 bursts of from 3 to 5 rounds each were fired. The firing was discontinued because of the fact that the legs of the mount had a movement of approximately $^1/_2$ in. each side of the centerline, and the resultant severe vibration in the fuselage had either jackknifed, loosened, or displaced 5 of the 15 fuses located in the forward fuse panel.

As a result of our investigation of this accident, specific recommendations pertaining to the switch were: (1) to replace the present-type limit switch with a micromatic type as soon as possible; (2) to provide a protection for the switch in the event personnel attempt to use it as a step; and (3) to enclose the switch in a cover to protect it from rain when the gun turret is in the extended position and the hatch is open.

Case No. 2.—Recently at one of our fighter bases on the East Coast, a jet fighter on a ground-control interceptor scramble mission received substantial damage in an aborted take-off accident. This was the lead aircraft of a two-ship element. The wing flaps were checked at 20°, and trim tabs were neutralized. The throttle was advanced to take-off r.p.m., the brakes released, and the take-off roll started. As the lead aircraft approached an indicated speed of approximately 130 m.p.h., a strong and steady rearward pull was exerted on the control column that was unsuccessful in lifting the nose wheel off the runway. As the aircraft continued down the runway with the speed increasing to approximately 150 m.p.h., three two-handed rearward stick attempts were made to raise the nose wheel. When these efforts were also unsuccessful, the pilot decided to abort the take-off. The throttle was immediately closed and heavy braking applied. However, the aircraft ran off the end of the runway, struck a ditch, and received substantial damage.

Since it was established that the nose wheel failed to lift off the runway despite all the pilot's efforts, a thorough inspection was made of the various items that could have accounted for this type of accident. The power plant and air-speed indicator systems were not involved in the accident, since the thrust and speed during the take-off were verified by the second aircraft that rode on the lead aircraft's wing and took off in the normal distance. Nevertheless, a power check of the engines and a test of the air-speed system were made. Both of these items were in satisfactory operational and functional condition. The take-off gross weight and the center of gravity position were determined to be within the allowable limits. Weather, which includes wind, gust, and temperature, was not considered as a factor. Also, maintenance records revealed that there had been no pertinent write-ups or modifications of the aircraft which would have had any bearing on the accident.

A thorough examination was made of the elevator and elevator tab control systems. This inpection revealed that these control systems operated smoothly throughout the entire range of movement with no evidence of binding, and all components were properly secured.

During the inspection of the cockpit, it was observed that the pilot's transition and training check list, enclosed in a stiff plastic case, was on the floor to the left of the control column and fastened by a strap to the left stirrup of the ejection seat.

Detailed inspection of the check list revealed that the plastic case had a fold approximately 5 in. from the top. The case was marked by a torn, ragged indentation approximately $1^1/_2$ in. by $^1/_2$ in. on the left-hand side and a break in the plastic at the bend. It was evident that the indentation and breaks were caused by pressure being exerted against the case. Also noticed were green smudges that could have been obtained only by pressure against the zinc chromate paint on the seat or on the control column structure.

After experimentation, the check list was placed in such a position that, during rearward movement of the control column, the folded check list was wedged tightly between the control column cradle and the base of the ejection seat. The points of contact coincided with the markings on the case. The check list in this position restricted the control column to full rearward travel by approximately $1^3/_8$ in. This restriction limited up-elevator travel to 19°, whereas the full travel is $27^1/_2$°. In this particular type aircraft, full up-elevator movement is required for take-off. The above restriction was sufficient to prevent the aircraft from becoming air borne. This case has been presented to show how accidents may result from simple causes.

As a result of our investigation, instructions were issued which specified a standard location in the cockpit for the placement of the check list, so that it will be easily accessible to the pilot without danger of interferences with the flight controls, system controls, switches, or instruments.

Case No. 3.—One of our cargo aircraft was declared missing while on a transoceanic flight. After an intensive search by aircraft and surface vessels, only small amounts of debris were recovered.

As a result of this accident, representatives of the Directorate of Flight Safety Research conducted comprehensive inspections of similar model aircraft during the manufacture, as well as a tear-down inspection of a sister aircraft that had had service time. The purpose of these inspections was to uncover possible items, in the design of the aircraft, its equipment, and installation, which might be considered a potential hazard to flight safety, and to check for service wear.

One of the deficiencies revealed was that the pitot static system did not have an alternate source of static pressure. If the source iced over, the situation could result in erroneous flight instrument readings. An alternate static source should be provided or provision made to heat the present source. Examination of the aircraft showed that all rudder, rudder tab, elevator, and elevator tab control cables are routed on the upper left side of the fuselage with only 10 in.

separation between the duplicate elevator control cables. Since the particular design of the propeller blade installed in the aircraft has failed on several occasions, it was possible that a failed blade may have severed the cables in this cable block and thrown the aircraft out of control. Since the regulation stipulates that the elevator controls must be duplicate, flight safety can be better fulfilled by placing these elevator cables on opposite sides of the fuselage. The requirement at present only stipulates that this be done for bombardment aircraft.

The investigation disclosed that the aircraft are equipped with electrically driven flight instruments. Complete electrical failure at night or during weather flying would require the pilot to fly the aircraft with only bank and turn indicator, compass, air-speed indicator and altimeter. This is not desirable for transatlantic flights of long duration. A set of vacuum instruments or a duplicate set of electrical flight instruments driven from a separate source of electrical energy and utilizing separate wiring would be cheap insurance for safety.

It was revealed that the firewall shutoff valves are electrically controlled. In case of electrical failure, the crew would be unable to operate these valves. This is an instance of design where the operation of an emergency system is dependent upon another system. To ensure operation of these valves at all times and in all emergencies, manually controlled firewall shutoff valves should be installed where feasible.

Wing and empennage heaters in this aircraft are used as deicers and not as anti-icers. This procedure is followed to prevent runback on the unheated portion of the wing. The heaters are not turned on until a moderate layer of ice has accumulated on the wings. As soon as the ice loosens and cracks off, the heaters are turned off, and the procedure is repeated as often as necessary. The danger exists that, if a heavy build-up of ice were suddenly encountered with the heaters off, it would be possible for the air intake duct to the heater to clog. These ducts are heated by the wing heaters, and, if they become clogged, the heaters would be inoperable.

Because of the extremely long flights made by aircraft of this type and the amount of weather flying it must do, the installation of air-borne radar equipment would prove valuable for circumnavigation of severe storm areas.

It was noted that the aileron control mechanism was in an under-floor cargo compartment mounted on the rear of the rear spar. This highly vital control equipment was separated from the compartment only by a light canvas curtain that, in nearly all of the aircraft inspected, was rolled and held in the up position. It would be very easy for articles carried in this compartment to move forward in rough air and jam this aileron control mechanism.

The pulleys and the cables for the rudder trim tab are located in the floor cutout of the fuselage tail area. There is no protection against jamming of this control unit from objects that could easily foul it. Also, in this portion of the fuselage, there is no protection against rain or snow entering the tail portion through large openings on the root ends of the rudder and elevator.

Both right and left fuel selector valves were found to be extremely vulnerable to jamming by articles falling out of the clothes of mechanics as they crawl through the wing leading-edge tunnels. No provision had been made to prevent such an occurrence.

Early in the investigation it was noted that failure of a propeller cuff or propeller blade itself could have a serious, if not catastrophic, effect on the aircraft. Not only are the control cables for the empennage clustered together, which would make them extremely vulnerable to this type of failure, but also vital parts of the aircraft are located in the plane of rotation of the propeller blades. These items are the racks that contain the radio equipment and such electrical units as the master propeller synchronizer and autopilot equipment, as well as the brackets that retain the various tanks for the entire oxygen supply.

At this time, the theory was presented that the probable cause for the accident could be a failure of some part of the propeller or the propeller-engine combination. This particular type of propeller construction and design has experienced five recorded failures during the time it has been in service. An accident of this nature could well fit the known facts and circumstances. A failed part of the propeller could project itself through the fuselage into the radio equipment which could account for the radio silence while the aircraft was cruising at the known altitude of 9,000 ft. This propeller failure could also have cut the empennage controls, damaged the electrical equipment, punctured the oxygen tanks, and cut lines containing hydraulic fluid.

Several months after the disappearance of the aircraft, an accident happened to a sister aircraft which strikingly fitted the details of the theory presented. During a take-off run, the sister aircraft experienced a failure of the aluminum-alloy cuff support casting from a blade of No. 3 propeller. The aircraft aborted its take-off and, by use of reverse thrust, was brought to a stop on the runway. None of the 61 personnel on the aircraft was injured.

The failure of the cuff support casting permitted the cooling cuff to move along the blade axis under the action of centrifugal forces and penetrate the lower right side of the fuselage. The penetration extended through the outer skin at the section reinforced by the protection strip and through the right- and left-hand corrugated panels of the nose-wheel well. Severe structural damage occurred to five longitudinal stringers and a heavy bulkhead. Three hydraulic lines in the compartment in front of the bulkhead were severed. The electrical master propeller synchronizer and certain autopilot equipment located in the rear of the bulkhead were destroyed, and several electrical wiring bundles

were cut. Brackets for the oxygen tanks are located directly in line with the hole punched in the structure by the cuff. Fortunately, oxygen tanks were not installed in the racks; otherwise, a disastrous explosion might have occurred.

The inspections that were instigated as a result of the missing aircraft and the investigation of the accident caused by the aborted take-off resulted in many recommendations that will help prevent future accidents.

Case No. 4.—Several months ago during a daylight take-off on a pilot transition training mission, a cargo aircraft crashed. Three landings had already been accomplished on this mission. During the fourth and final take-off the aircraft made a normal acceleration down the runway. At the point of take-off, wings were level. There was no crab, and wind conditions were negligible. The aircraft had just become airborne when the right wing dropped and dragged over the ground, which caused the aircraft to cartwheel. As the aircraft was turning and dragging over the ground, propeller blade slashes were made in the earth by No. 4 propeller.

The aircraft was totally destroyed by the forces of impact and subsequent fire.

The propeller domes were examined, and it was indicated from impact marks on the sector gearing that the blade angles on No. 1, No. 2, and No. 3 engines were forward of the low-pitch stop in the governing range. The impact marks on the gearing for No. 4 propeller were below the low-pitch stop which indicated reverse pitch operation. Analysis of the fractures to the No. 4 propeller blades showed tension failures on the camber or forward side and a combination of tension, compression, and shear failures on the thrust or aft side. An examination of the blade marks in the earth and a fitting of the blade tip in these slashes revealed that the trailing edge of the blade was forward of the leading edge at the time of contact with the ground. From the items as stated—namely, the markings on the sector gearing below the low-pitch stop, the tension fracture on the forward side of the blade, and the imprint in the ground—it was evident that No. 4 propeller was in reverse pitch.

Interrogation of witnesses indicated that, just as the aircraft became air borne, an unusual engine or propeller noise was heard. From the facts and circumstances as presented, it is evident that No. 4 propeller must have reversed immediately as the aircraft became air-borne.

Examination of the reverse mechanism in the pilot's throttle quadrant revealed that, in order to reverse the propeller, the throttle latches must be raised over a $^{3}/_{16}$-in. stop. However, the overlap of the latch on the stop is only $^{1}/_{8}$ in. The faces of the latch are on a bevel designed to lift easily the throttle latch over the stop while pulling aft. It was demonstrated that by grasping any one throttle and flicking it back, the throttle jumped by the stop into the reverse position.

Since the test program for this flight called for a simulated engine failure, it was the finding of the accident investigating group that the instructor pilot retarded No. 4 throttle to simulate an engine failure. In so doing, the throttle passed over the stop and activated the reverse-pitch cycle.

As a result of this accident, recommendations were made to redesign the throttle reverse mechanism for a positive stop which would preclude any possible inadvertent operation of the reverse-propeller cycle. Since inadvertent propeller reversals have also occurred on other model aircraft, this recommendation was also made to pertain to all aircraft.

Case No. 5.—For a number of years there have been accidents in fighter-type jet aircraft wherein fire and explosion occurred shortly after take-off. Careful investigation revealed that the source of fuel for these explosions and fires came from the fuselage tank fuel filler well as a result of improperly secured fuel caps. The fuel flow out of the filler neck formed a combustible fuel-air mixture on the forward side of the engine. It needed only a source of ignition to set off a catastrophic explosion, and in jet engines there are numerous hot spots that could act as a detonator for this explosive vapor mixture.

As soon as this critical condition became manifest, all jet aircraft using agencies were notified to be extremely vigilant in preflighting aircraft to check that the fuel tank caps were properly secured. A recommendation was made that all fuel tank filler cap doors be redesigned to ensure that the outer access door could not be closed and locked without the inner fuel cap being secured in its recess. When this modification finally became a reality in the field, it was soon discovered that it also was inadequate. An accident, occurred which resulted in many fatalities, on an aircraft equipped with this modification. As a result of this accident, a remodification of the modification had to be retrofitted.

These cases that have been brought to your attention are typical of many hundreds of other accidents that are causing a shameful loss to the nation of highly trained personnel and many millions of dollars.

Reviewing the factors that caused these accidents revealed:

(1) The lack of design planning in installing an inferior type of limit switch to control a vital precision part.

(2) The lack of safety thinking in failure to provide a safe space for a check list.

(3) The lack of understanding of the primary concepts of safety in not providing protection from jamming of vital control units of the aircraft and in locating vital equipment in line with the plane of rotation of the propellers.

(4) The lack of proper functional design in manufacturing a propeller reversing mechanism that could easily malfunction.

(*Concluded on page 43*)

Cross-Country Soaring Criteria Based on Thermal Strength

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Introduction

Of the many different forms of atmospheric energy available for soaring flight, by far the most common, and therefore the most widely used, is the thermal column. Of the types of soaring flight in practice, the distance flight that requires the highest degree of excellence of the sailplane and pilot has justifiably taken the lead in importance. At our present state of aerodynamic development and meteorological knowledge, this type of flight is characterized by an altitude gain while circling in the thermal column, followed by a loss of altitude in the straight glide to the next thermal. Although future development may lead to cross-country soaring of a more satisfactory type, this paper examines the present state of the art and seeks to maximize the performance.

Definitions

Net Performance

t_g = time spent in glide between thermals
t_c = time spent in climb, spiraling in thermals
w_g = rate of descent in glide between thermals
w_c = rate of ascent, spiraling in thermals

Air-Mass Motion

v_a = vertical air-mass velocity between thermals
V_{th} = vertical air-mass velocity in thermals

Sailplane Still-Air Performance

$V_{\text{eff.}}$ = effective cross-country speed, distance/total time
V = air speed used between thermals, variable
V' = air speed for best glide ratio
w_s = sinking speed as a function of air speed
w_s' = sinking speed at best glide ratio

Sailplane Characteristics

C_{D_0} = minimum drag coefficient, sum of profile and parasite
$e.AR$ = effective aspect ratio
W/S = wing loading in pounds per square foot

It will be noted that the dimensions are omitted in a majority of definitions. This is because most of the analysis and results are given in nondimensional ratio form. At first glance such a system may be confusing to those accustomed to working with absolute values. However, it is an invaluable aid in this type of study, greatly reducing the labor involved in the calculations and providing a more general and therefore useful result. Thus, although the characteristics of the sailplane and the air mass under study may vary, the basic relationships established here remain true and can easily be applied to the particular conditions under study. Where dimensions are used, air speed is in miles per hour and sinking speed is in feet per second in line with American instruments.

Presented at the Motorless Flight Session, Twentieth Annual Meeting, I.A.S. (Joint Session with the Soaring Society of America, Inc.), New York, January 28–31, February 1, 1952.

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The Basic Equation

With the number of hours of thermal activity in a given day limited, the attainment of record distance is dependent on high effective ground speed. If appreciable horizontal winds are expected to maintain a steady direction over terrain possessing good thermal activity and adequate fields for landing, it is obvious that their utilization can be of great aid. Since in steady flight the sailplane's air performance is independent of the wind measured from the ground, no further account need be taken of the wind in the ensuing discussion. The optimum technique worked out for no-wind conditions will still be optimum with wind present. The only result of the wind will be to change the absolute value of the effective ground speed or distance obtained.

Since speed is simply distance divided by time, and in the type of flight under study distance is only gained between thermals, we may write the equation for effective cross-country speed in its simplest form:

$$V_{\text{eff.}} = V \cdot t_g/(t_g + t_c) \tag{1}$$

Now, since it is unwise to lose more altitude between thermals than is gained, the time values in Eq. (1) are replaced with rates of ascent and descent by equating altitude lost to altitude gained:

$$V_{\text{eff.}} = V \cdot w_c/(w_c + w_g) \tag{2}$$

These rates will now be examined in more detail.

Rate of Ascent in the Thermal

The average rate of ascent in the thermal is equal to the difference of the vertical velocity of the thermal and the sinking speed of the sailplane in circling flight. The strength of the thermal diminishes with distance outward from the core, but the sinking speed of the sailplane increases as the turning radius is decreased. There must be an optimum, but the present knowledge of the structure of typical thermals is too limited to allow precise expression. Experience of soaring pilots indicates that a 40° banked turn appears to be optimum for contemporary sailplanes.

The lift required in turning flight is equal to that required in straight flight divided by the cosine of the bank angle. For optimum bank the induced drag is increased about 70 per cent, since it is proportional to the square of the lift coefficient, and the total drag or sinking speed is increased by 50 per cent. Since the remaining mathematical treatment will be simpler if all flight conditions are referred to those at maximum

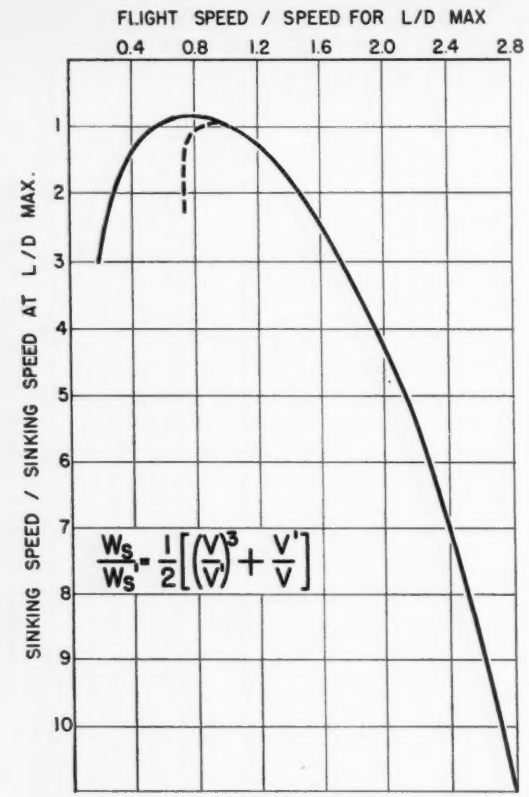

FIG. 1.

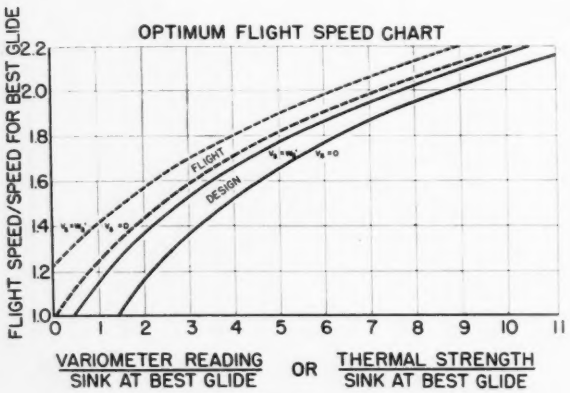

FIG. 2.

glide ratio, the sinking speed in the turn can be expressed as 1.32 times the sink at best glide ratio, since minimum sinking speed is 88 per cent of the sink at best glide ratio. Eq. (3) may now be written as

$$w_c = V_{th} - 1.32w_s' \tag{3}$$

RATE OF DESCENT BETWEEN THERMALS

The sinking speed between thermals will be equal to the sum of the downdraft strength and the still-air sink of the sailplane (which is a function of the air speed). The general analytical study may appear stymied at this point, since each sailplane has a different sinking speed-forward speed polar. However, when viewed from the proper perspective, all airplane polars are basically similar. Dr. Max Munk has expressed this similarity in his universal performance function.[1] By choosing the condition of maximum glide ratio as a reference point, the flight polar can be expressed as a nondimensional sinking-speed ratio against a nondimensional flight-speed ratio. Fig. 1 presents this graphically, and it can be seen that, regardless of the sailplane flown, if the plane is operating at twice the speed for best glide ratio, the sink will be 4.25 times as large as it was at best glide. Note also that the minimum sink is 88 per cent of sink at best glide and occurs at 76 per cent of best glide speed. As pointed out to the writer by Dr. Joachim Kuettner, when several modern sailplane polars are nondimensionalized, there is a scatter of data about the theoretical polar. At low speeds, the early fall-off is due to flow separation at the high lift coefficients. The discrepancies at the higher speeds which are of interest to this study are due to a variety of reasons and are not of large order. Thus, the theoretical polar will suffice for this study and Eq. (4) can be written as

$$w_g = v_s + \frac{w_s'}{2}\left[\left(\frac{V}{V'}\right)^3 + \frac{V'}{V}\right] \tag{4}$$

THE DETAILED BASIC EQUATION

Eq. (5) is obtained by substituting Eqs. (3) and (4) in Eq. (2).

$$V_{\text{eff.}} = \frac{V(V_{th} - 1.32w_s')}{(V_{th} - 1.32w_s') + (w_s'/2)\left(\frac{V}{V'}\right)^3 + (w_s'/2)\left(\frac{V'}{V}\right) + v_s} \tag{5}$$

It can be seen that the equation now contains the meteorological data (thermal and downdraft strength) and the flight and sinking speed at best glide ratio plus the variable flight speed V. The equation suggests two possibilities of flight optimization. First, a solution for optimum flight speed between thermals will be investigated, and then an attempt will be made to determine the optimum relationship between the sinking speed at best glide ratio (a measure of the degree of ballasting for a given design) and the meteorological conditions.

OPTIMUM SPEED BETWEEN THERMALS

In the early days of cross-country soaring, sailplanes were flown at practically constant speed regardless of air-mass conditions. Gradually, the more perceptive pilots began to realize that, when strong thermals gave them a safe margin of altitude, they could increase their cross-country speed by using higher air speed between thermals without too great a risk of flight termination. It was a guess-and-gamble proposition, and even the better pilots had difficulty obtaining consistent successes. In 1937, the Polish engineer,

Kasprzyk, evolved the relationship analytically. The following year, the Polish team narrowly missed winning the International Meet, where they had the disadvantage of flying over unfamiliar terrain.

Papers on this subject have been written in Switzerland, Germany, Finland, England, and the United States over the past several years. It is the purpose of the following paragraph to generalize the result so that it can be applied to any sailplane for which the sink and forward speed at best glide ratio are known.

If Eq. (5) is differentiated with respect to the flight speed V, set equal to zero and rearranged, the following equation results:

$$\frac{V_{th}}{w_s'} = \left(\frac{V}{V'}\right)^3 - \frac{V'}{V} + 1.32 - \frac{v_s}{w_s'} \qquad (6)$$

We note that the velocity ratios appear as before and that the air-mass motions are expressed in terms of a known sailplane characteristic. Thus the result can be kept perfectly general. The equation, however, is a quartic of a most unpleasant variety. While the pure mathematician may enjoy solving it for the velocity ratio and sorting out the extraneous roots, the author prefers to use the less time-consuming process of substituting values of v_s/w_s' and V/V' and solving for V_{th}/w_s'. These results are plotted in Fig. 2. The solid lines are of interest to the designer and in this case the abscissa denotes the thermal strength. Downdraft strength of zero and downdraft strength equal to still-air sink at best L/D are presented allowing interpolation for other values. The dashed lines are presented for the benefit of the pilots who do not have a value of thermal strength before them but have the net result of this value and the still-air sink of the sailplane—the variometer reading. We see that the speeds increase at a gradually decreasing rate as the thermal strength increases. When the thermal is just equal in strength to the sink of the sailplane in the spiral (variometer reading zero), the pilot should (as common sense dictates) cease spiraling and, if there are no downdrafts present, fly at best L/D. For the large downdraft chosen for study, it is necessary to fly about 22 per cent faster. If the variometer should indicate an ascent of five times the still-air rate of descent at best L/D, the pilot may fly 77 per cent in excess of best glide speed if no downdrafts are present. Downdrafts, of course, call for even higher speed.

If the value of sinking speed at best glide ratio and the air speed at which best glide occurs are known, then, from the general information of Fig. 2, a curve of optimum flight speed vs. variometer reading in the climb for a particular sailplane can be constructed. If an accurate flight polar is available, a more accurate curve can be obtained with somewhat more effort by substituting values of air speed and corresponding values of still air sinking speeds in Eq. (2) for various values of thermal strengths.

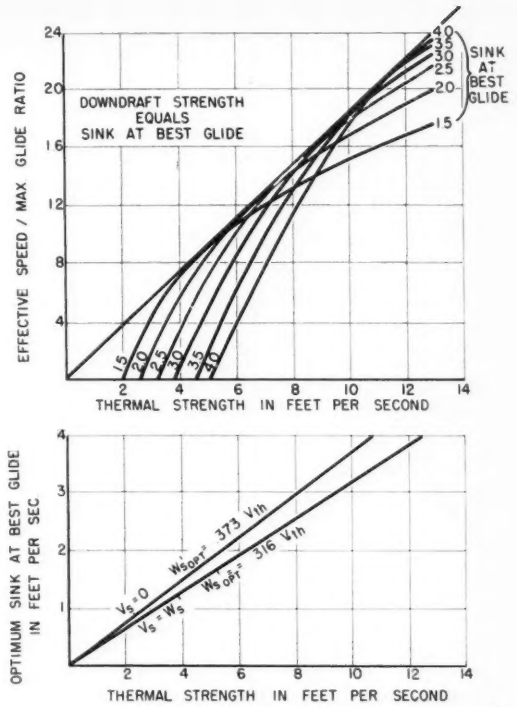

FIG. 3. Graphical solution of optimum sink at best glide.

FINDING THE OPTIMUM SINK AT BEST GLIDE RATIO

In addition to choosing the best air speed at all times, further gains in distance flying are possible through the use of ballast. Soaring pilots have resorted to this expedient on several occasions in the past. The first instance (to the best of this writer's knowledge) was by Wolf Hirth, of Germany. The all-metal Schweizer 1-21 and 1-23 sailplanes in this country have had provision in the wings for water ballast which can be jettisoned in flight. The speed at which a sailplane obtains its best glide ratio is a function of the lift coefficient and the wing loading. The lift coefficient is uniquely defined by the aerodynamic characteristics of the sailplane. Decreases in the minimum drag lead to an increase in both $(L/D)_{max.}$ and the speed at which it occurs.

Unfortunately, increases in effective aspect ratio, while yielding large gains in $(L/D)_{max.}$, require higher lift coefficient, which in turn results in lower air speed. Thus, ballasting is required to obtain a high flight speed for best glide. This in turn will result in higher sinking speeds. The ensuing study will seek to determine the optimum relationship between sink at best glide and the thermal strength.

The equation for effective cross-country speed may be written as

$$\left.\begin{aligned} V_{\text{eff.}} &= (V_{\text{eff.}}/V)\cdot(V/V')\cdot V' \\ &= K\cdot(V/V')\cdot w_s'\cdot(L/D)_{max.} \end{aligned}\right\} \qquad (7)$$

where Eq. (2) may be transposed to give the efficiency factor,

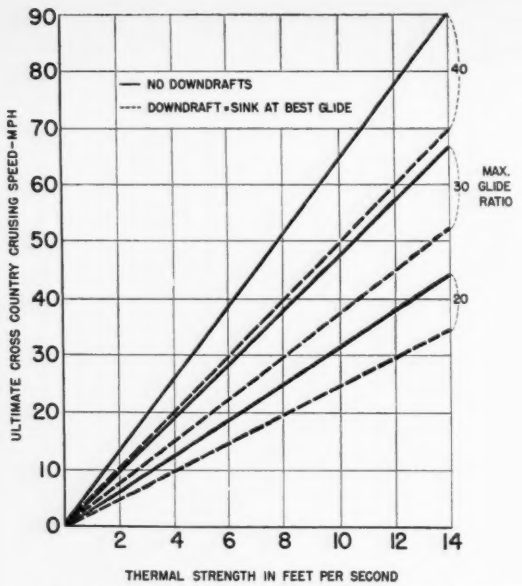

FIG. 4. Ultimate performance for constant thermal strength.

$$K = \frac{[(V_{th}/w_s') - 1.32]}{[(V_{th}/w_s') - 1.32] + [(w_s/w_s') + (v_s/w_s')]} \quad (8)$$

For chosen values of thermal and downdraft strength, refer to Fig. 2 to obtain the optimum-speed ratios. These ratios are used in conjunction with Fig. 1 to get the sinking-speed ratios. All of these may then be combined to obtain the values of optimum K by substituting in Eq. (8).

The procedure now is to assume several trial values of w_s' for each thermal strength investigated. The ratio of these two plus the value chosen for downdraft strength will yield all the information necessary for substitution in Eq. (7). The value of $(L/D)_{max.}$ can be temporarily removed from the work, since it affects only the absolute value of effective speed. Fig. 3 shows the results of such a calculation in the form, effective speed/maximum glide ratio vs. thermal strength. Each curve representing a given value of sink at best glide falls tangent to the same straight line through the origin. Thus, for each value of thermal strength there is a particular value of sink at best glide which will yield the best cross-country speed. Fig. 3b shows this relationship for two different assumed downdraft strengths. Interpolating for a typical value found in practice indicates the optimum value of sink at best glide is approximately one-third of the mean thermal strength.

Effective Cross-Country Speed

Fig. 4 shows some maximum values of cross-country speed which could be obtained with sailplanes having $(L/D)_{max.}$ of 20 (low-performance sailplane), 30 (until recently a high-performance sailplane), and 40 (best sailplane at present—RJ-5). Since this parameter is so important, some consideration should be given to it here. In general, high aspect ratio must be exploited to the point where drag starts to increase appreciably by reason of excessive airfoil thickness or wing flexibility. The parasite drag must be kept to a minimum by making the fuselage and tail surfaces as small as practical, of good form, and with carefully designed intersections. Although sufficient information is not always available, considerable study should be expended on the choice of airfoil section. All gaps must be well sealed to avoid leakage drag. For superior performance, it is necessary to obtain a considerable percentage of laminar flow in the boundary layer of the sailplane. To date this has been accomplished by holding the surface wave and protrusion free to one or two thousandths of an inch. This necessitates either expensive production fixtures or thousands of man-hours of handwork. The future may reveal less tedious methods of controlling the boundary layer. Returning to the optimistic speed figures of Fig 4, it should be remembered that they are optimum values based on constant thermal strength, the optimum ballast to match it, and perfect choice of air speed by the pilot.

Optimum Wing Loading

Thus far, only the optimum value of sink at best L/D has been indicated. Fig. 5 shows this value, together with the aerodynamic qualities of the sailplane from which the desired wing loading can be determined. The lift coefficient for best glide is a function of the effective aspect ratio and minimum drag coefficient as shown in the upper left quadrant of the

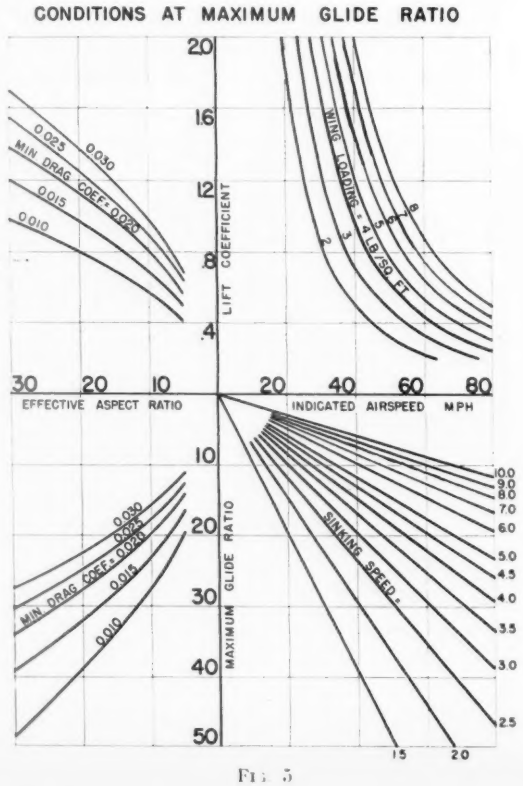

FIG. 5

figure. The maximum glide ratio is a function of the same two parameters as shown in the lower left quadrant. The air speed for best glide follows directly from the sink at best glide and the glide ratio and is given in the lower right quadrant. Since lift must equal weight, the wing loading follows from the lift coefficient and air speed already determined and may be found in the upper right quadrant of the figure. The formulas involved are given below:

$$C_{L_{opt.}} = \sqrt{\pi\ eAR\ C_{D_0}}$$

$$V_{m.p.h.}{}' = [w_s{}'_{f.p.s.} \cdot (L/D)_{max.}]/1.467$$

$$(L/D)_{max.} = (1/2)\sqrt{\pi\ eAR/C_{D_0}}$$

$$(W/S)_{opt.} = C_{L_{opt.}}[(V_{m.p.h.}{}')^2/391]$$

Practical Application

There is no longer any question that the optimum air speeds can be chosen with reasonable accuracy and used to advantage on good soaring days. The success of MacCready in all the speed events at Orebro and Johnson's remarkable distance flights out of Odessa should serve as valuable lessons to all serious soaring pilots. A curve of optimum flight speed vs. rate of ascent in the last thermal may be expected to be standard sailplane equipment in future soaring meets.

The use of water ballast requires further investigation. The study presented here has obtained an analytical relationship between optimum ballast and thermal strength which is only as good as the assumptions involved. The turning flight assumptions are particularly brief as insufficient information is available at this time on the structure of thermals. This study is advanced, then, to stimulate the thinking of others along similar lines and should not be regarded as the final word.

Since meteorologists cannot consistently predict from general synoptic data what the mean thermal strength of the day may be, the difficulty may be overcome by delaying take-off until a radio-equipped sailplane can make a survey flight and relay data on thermal activity.

In the case of overestimating thermal strength before take-off, ballast may always be jettisoned. It is hoped that more pilots will experiment with this method of increasing cross-country performance. Perhaps high-efficiency cross-country soaring will require the development of a reversible ballasting procedure or a variable area wing of exceptional aerodynamic refinement. It should be remembered that the possibilities of soaring flight are limited only by the imagination and the determination to prove by experiment the theories thus provided.

Reference

[1] Munk, Max M., *Performance Calculations*, Aero Digest, Vol. 43, No. 5, November, 1943.

Safety in Design

(*Concluded from page 38*)

(5) The lack of sufficient foresight in not designing a fuel tank cap and cover that would be operationally foolproof.

Conclusion

Review and study of these items, which have caused such a loss, yield the astonishing fact that these accidents were caused by small design and installation details in the aircraft which have been neglected. It appears that all the brains and energy have been expended on obtaining an aircraft whose structure is airworthy and which is aerodynamically supreme. Details of systems, equipment, and their installation have been grossly neglected.

In order to attack and destroy this insidious factor that at present is continuously working against our program of Air National Defense we must strike at the source of the trouble. In order to do this, it is recommended that aircraft manufacturing companies establish within their organizations a department of safety engineering on staff level, the personnel to consist of men with diversified experience in the aeronautical industry and who have an inherent interest in flight safety, a curiosity for details, and an uninhibited vision. From the very beginning of a prototype design, this department would work in unison with the design engineering departments. Since the design engineering department's maximum effort is toward a compromise of weight and performance, the safety engineering department's effort would be toward inherent built-in safety. In this way, safety engineers would be diagnosticians instead of morticians.

For lack of a better descriptive phrase, "safety consciousness" has been used. It must be realized that the lack of safety consciousness in aircraft engineering is far more reaching in its effects than generally realized. There is not only a loss in highly trained men and valuable aircraft but also there is usually inaugurated an expensive retrofit program. This retrofit program, in turn, ties up engineers, material, shop equipment, and mechanics, and the aircraft themselves are withdrawn from service. None of these items, even during normal times, is acceptable. In the emergency of today, such items are untenable. It is apparent that safety consciousness in aircraft engineering is of paramount importance, if we are to attain the ultimate in potential operational efficiency and provide the maximum fulfillment of our National Defense Program.

Criteria for the Design, Assessment, and Control of Icing Protection Systems*

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SUMMARY

Icing parameters can be classified into two groups: a "severity" group, which affects the design, and a "distribution" group, which is of operational significance. When the influence of each parameter is considered, it is possible to decide which parameters are most important and to select these to determine maximum design conditions.

Since it may prove impractical to design for these maximum conditions, a method is shown of assessing any new or existing protective system in terms of the statistical probability of encountering icing severities that exceed the capabilities of the system.

Operational requirements are also suggested, from which it is evident that considerable economic advantage can be obtained by controlling the degree of protection to suit ambient icing conditions. The need for more statistical data is stressed, and since both the collection of data and the control of icing protection depend on simple and serviceable icing instruments, a short discussion on these is included.

It is concluded that design and operational requirements can be put in a logical form, that an assessment of the "ice-worthiness" of protection can be made, that the control of protective systems is necessary, that more icing data are still required, and that the means for obtaining these data are largely available.

(1) INTRODUCTION

THE IMPORTANCE OF THE aircraft icing hazard and the degree of icing protection required are still subjects of controversy, mainly because it has not so far been possible to present the icing problem in perspective. Thus, one is not yet able to obtain general agreement on icing requirements, to make a sound assessment of a given protective system, to compare different types of protection, to plan operations on a safe but economical basis, or even to make a firm meteorological forecast, because the usual approach to these questions is a matter of estimation, guessing, and personal experience.

However, some icing data have been obtained, and this paper considers the basis on which these should be used, adds a plea for more icing statistics, and discusses methods of collecting them.

Presented at the Meteorological Session, Twentieth Annual Meeting, I.A.S. (Joint Session in Cooperation with the American Meteorological Society), New York, January 28–31, February 1, 1952.

* Some of the meteorological information used in this paper was obtained from private communications from the British Meteorological Office.

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(2) ICING PARAMETERS

Icing data can be classified into two groups: a "severity" group, which defines the immediate icing condition, and a "distribution" group, which refers to occurrence and extent.

The *severity* parameters (which include air temperature, liquid water content, droplet size, and pressure altitude) affect the flow and coverage†† required of icing-protection systems, as shown in Table 1 (where the power requirement of a deicing system is regarded as a flow).

It is clear that this group defines the basic design of a system and that for flow requirements the important icing parameters are air temperature and liquid water content: for coverage requirements, droplet size (and, in certain cases, temperature and water content).

The aircraft parameters of scale and velocity are also design conditions, although not directly icing parameters.

The *distribution* parameters are geographical and seasonal occurrence, lateral and vertical extent, and variation. These are of operational significance and define the "amount"—that is (flow × time)—of icing protection required.

(3) METEOROLOGICAL DESIGN REQUIREMENTS

The principal design variables are flow and coverage, which can be treated separately.

Flow Requirements

Liquid water content, m, and temperature below freezing, θ, are the primary factors in determining the flow requirements for any protective system. Droplet size has only a minor effect on flow, so that no undue penalty is imposed by considering only the maximum probable droplet size. The most adverse pressure and velocity conditions should be used.

Flow design requirements can thus be expressed in the form of the m, θ diagram of Fig. 1. In this figure the shape of the suggested maximum requirement envelope is based on the following arguments: While the largest value of m so far recorded in flight is less than 3 Gm. per cu.m., the theoretical maximums for temperate convective clouds are of the order of 6 Gm. per

†† Coverage is used as a term for the chordwise or lateral extent of icing protection.

cu.m. Therefore, to be safe and to allow for the limitations of measured values [see Section (8)], it is felt that a maximum liquid water content of 4 or 5 Gm. per cu.m. should be specified. Both theoretical and measured values of total free water content* tend to peak at $-10°$ to $-20°$C. Beyond about $-15°$C., glaciation and precipitation may be expected to reduce the liquid water content. At $-40°$C., practically all the free water in the cloud will be in the frozen state.

For systems of icing protection with good recovery characteristics (i.e., which can melt or shed ice accumulated during extreme conditions), "extent" envelopes are shown for 10 and 20 miles. From these envelope curves it is possible to determine the maximum design point required for each particular protection system, noting that kinetic temperature effects provide an effective higher limit to θ.

It is not yet possible to assign critical values to these flow design requirements, because of insufficient information on maximum values of m.

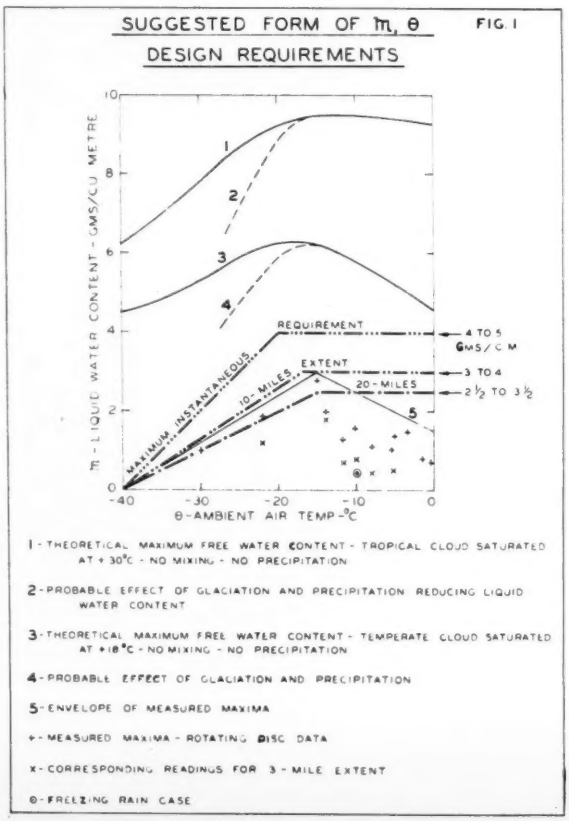
Coverage Requirements

From the data of Fig. 2,[1–4] it will be reasonably safe to design coverage to a maximum droplet size of 50 microns diameter. For deicing systems, it will also be necessary to consider m and θ because of runback. The highest value of θ, corrected for kinetic rise effects, and the associated maximum value of m in Fig. 1 should be used.

For certain engine installations (where, because of curvature of the air intake) the coverage required may increase with reduction in drop size, a droplet diameter of 10 μ should also be considered.

Freezing Rain.—For the special case of freezing rain, which will affect coverage but not flow, 1000 μ diameter droplets at $-10°$C., with a liquid water content of 0.5 Gm./cu. metre, are the design conditions suggested, till more data are available.

* In this paper a distinction is made between "free water content," which includes both the liquid and solid states, and "liquid water content," which refers only to supercooled water.


SUGGESTED FORM OF m, θ
DESIGN REQUIREMENTS
FIG. 1
m - LIQUID WATER CONTENT - GMS/CU METRE
θ - AMBIENT AIR TEMP - °C
REQUIREMENT
EXTENT
4 TO 5 GMS/C M
3 TO 4
2½ TO 3½
10 - MILES
20 - MILES
MAXIMUM INSTANTANEOUS
1 - THEORETICAL MAXIMUM FREE WATER CONTENT - TROPICAL CLOUD SATURATED AT +30°C - NO MIXING - NO PRECIPITATION
2 - PROBABLE EFFECT OF GLACIATION AND PRECIPITATION REDUCING LIQUID WATER CONTENT
3 - THEORETICAL MAXIMUM FREE WATER CONTENT - TEMPERATE CLOUD SATURATED AT +18°C - NO MIXING - NO PRECIPITATION
4 - PROBABLE EFFECT OF GLACIATION AND PRECIPITATION
5 - ENVELOPE OF MEASURED MAXIMA
+ - MEASURED MAXIMA - ROTATING DISC DATA
x - CORRESPONDING READINGS FOR 3 - MILE EXTENT
⊙ - FREEZING RAIN CASE

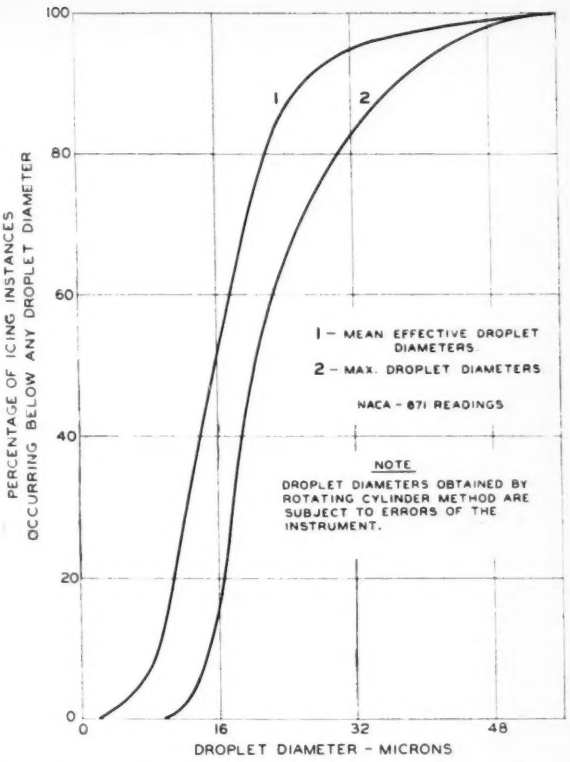

PERCENTAGE OF ICING INSTANCES OCCURRING BELOW ANY DROPLET DIAMETER
DROPLET DIAMETER - MICRONS
1 - MEAN EFFECTIVE DROPLET DIAMETERS
2 - MAX. DROPLET DIAMETERS
NACA - 671 READINGS
NOTE
DROPLET DIAMETERS OBTAINED BY ROTATING CYLINDER METHOD ARE SUBJECT TO ERRORS OF THE INSTRUMENT.

FIG. 2. Frequency of occurrence of icing instances below any droplet diameter.

(4) Design Assessment

It may prove impractical to design for these maximum conditions, and the majority of existing icing protection installations fall short of the probable quantitative values that appear on Fig. 1. It is thus necessary to have some way of assessing the degree of protection of such designs or systems.

Simplified Case

If the flow requirements for a system varied linearly with only θ, the temperature below freezing, and m, the liquid water content, then the performance of the system could be expressed as

$$m\theta = F \qquad (1)$$

A number of curves of $m\theta = F$, for various values of F, can be drawn on an m, θ scatter plot, as shown in Fig. 3. (The actual points on this figure are taken

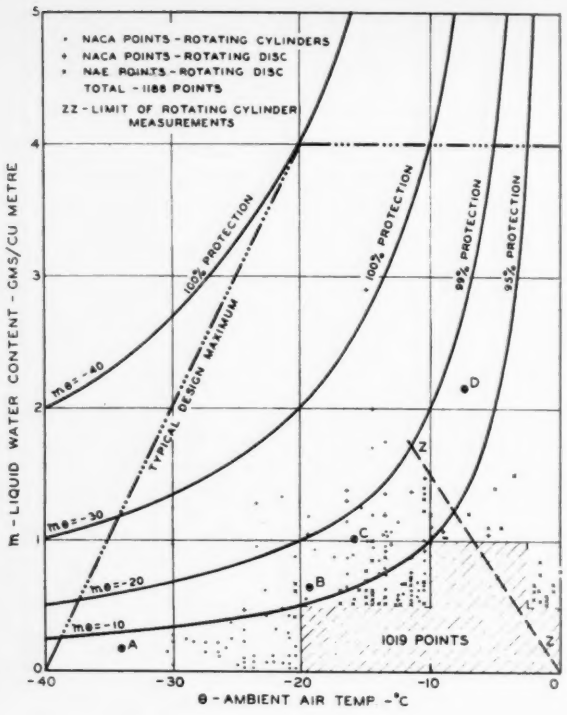


FIG. 3. m, θ diagram with scatter points.

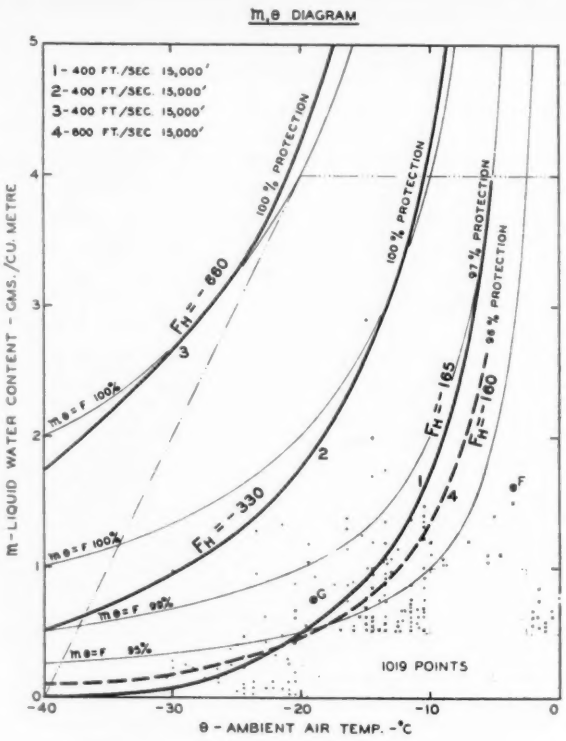


FIG. 5. Alcohol spray.

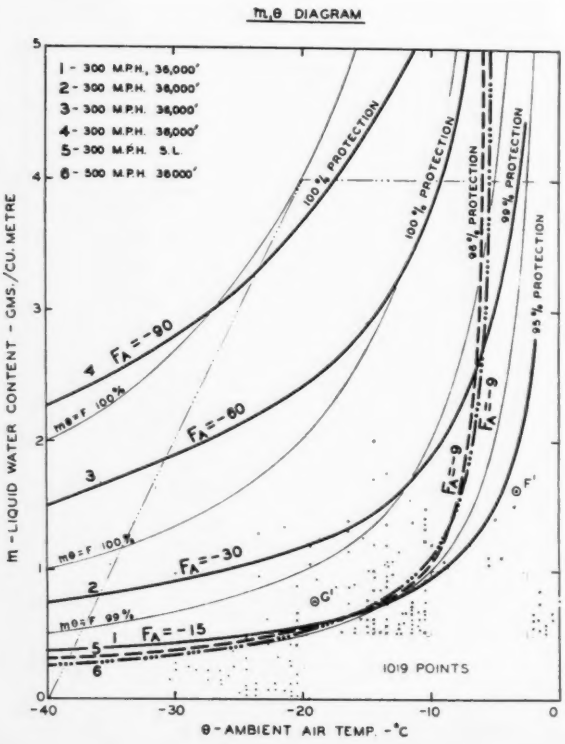


FIG. 4. Thermal anti-icing.

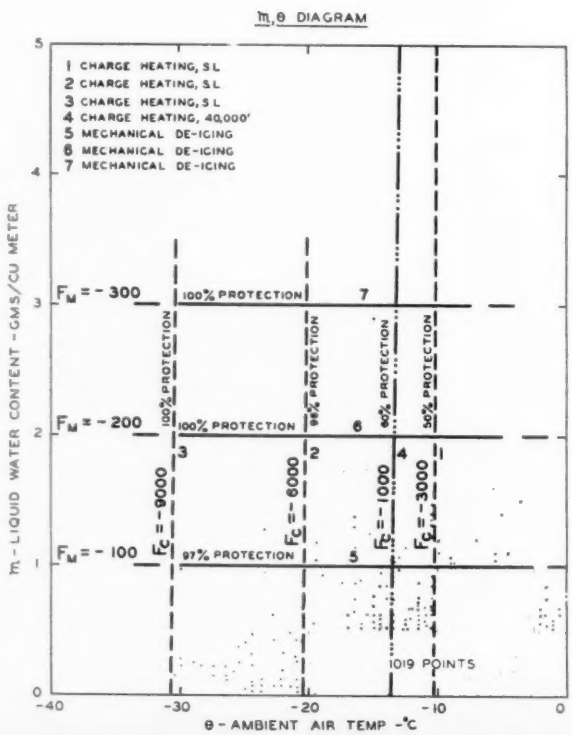


FIG. 6. Charge heating and mechanical deicing.

from all the available N.A.E. and N.A.C.A results.[1–7]) Each of these performance or flow curves envelopes a certain percentage of the scatter points. Thus any given flow of protection can be assessed in terms of the statistical percentage protection that it gives on the basis of existing data.

A typical flow curve could, in fact, be drawn through any single test or design point to give the percentage protection afforded by the relevant system. Even if a number of test points, A to D, were plotted, and the curve through them did not quite conform to the shape of the typical curves, it would still be possible to estimate the protection afforded by interpolation.

Particular Cases

In fact, the generalized flow equation for protective systems is more of the form

$$(Ehm + k)\ (\theta + \Delta\theta) = F \qquad (2)$$

where

E = collection efficiency
h = water-heating term
k = evaporative and convective term
$\Delta\theta$ = kinetic temperature rise

It can be shown that the approximate form of the expression, for various systems, is: for thermal anti-icing (Fig. 4),

$$(Ehm + k)\ (\theta + \Delta\theta) = F_T \qquad (3)$$

for alcohol spray anti-icing (Fig. 5),

$$Em(\theta + \Delta\theta') = F_A \qquad (4)$$

for electro-thermal shedding,

$$Em(\theta + x) = F_E \qquad (5)$$

for mechanical shedding (Fig. 6),

$$Em = F_m \qquad (6)$$

for charge heating (Fig. 6),

$$\theta + \Delta\theta = F_C \qquad (7)$$

In these expressions, E is a function of velocity, droplet size, and scale; h is a function of θ; k is a function of θ, pressure, velocity, and scale; $\Delta\theta$ is a function of θ and velocity; $\Delta\theta'$ also depends on the alcohol/water ratio; and x is an as yet undetermined factor.

Thus, the expressions cannot be applied in their generalized form, so that m, θ curves such as those shown in Figs. 4–6 can be drawn only for specific values of velocity, droplet size, pressure, and scale.

Application of m, θ Diagrams

For any given type of protection, it should be possible to draw a family of theoretical flow curves for the most critical conditions of velocity, droplet diameter, pressure, and scale. Each flow curve will represent a certain percentage of protection on the basis of the m θ scatter plot. Thus, if the design flow is known, the design percentage protection can be decided immediately from these flow curves.

If the assessment is to be based on test results, a single experimental point will define a theoretical flow curve and therefore give a basis for assessment, or a number of points will define an experimental curve, which can be assessed either by interpolation from the theoretical curves or directly from an m, θ scatter plot.

Consider a fairly specific case of flight-test approval of an aircraft with thermal anti-icing on the wings and alcohol deicing for the engines. Suppose the worst icing conditions successfully encountered by the aircraft were corrected for the effect of droplet size and then plotted as shown by F and F' on Figs. 4 and 5, respectively. Point F would demonstrate that there existed at least 60 per cent protection for the wings; point F′, 90 per cent protection for the engines. The aircraft would then be approved for flight in 60 per cent of icing conditions—i.e., perhaps, to fly through forecast light icing conditions.

If, later, the aircraft successfully encountered icing conditions represented by G and G', then the approval would be raised to 97%, which might mean flight through forecast moderate conditions.

It should be noted that, when more icing data is obtained and a fresh statistical analysis is made, there will be no need to change the curves, only the percentage figure attached to each curve being altered.

(5) Operational Requirements

As already indicated, operational requirements define the amount of additional fuel or of alcohol to be carried. This will be largely dependent on operating altitudes, routes, and seasons, which must therefore be taken into account.

Thus for an appreciation of the operational requirement, it would be necessary to have two sets of curves: Fig. 7, showing occurrence of icing instances at various altitudes.[1,8] Fig. 8a, showing maximum horizontal extents of average liquid water content, m_a, at various temperatures[1,6] or Fig. 8b, showing total icing encountered for various extents, which is, perhaps, a more directly useful presentation. These figures should be particular for given routes or geographical area and also for given seasons.

Fig. 7 shows the probability of encountering any icing and can only be used for flight-planning altitudes. (It should be noted that the apparent altitude limit of 24,000 ft. shown in Fig. 7 is not valid because of a lack of data for higher altitudes.) Figs. 8a and 8b, however, indicate the maximum amount of icing protection likely to be required, which, at a given temperature, will be proportional to (average liquid water content × extent) or to total icing encountered. This, of course, applies only when the flow is metered according to the ambient icing severity.

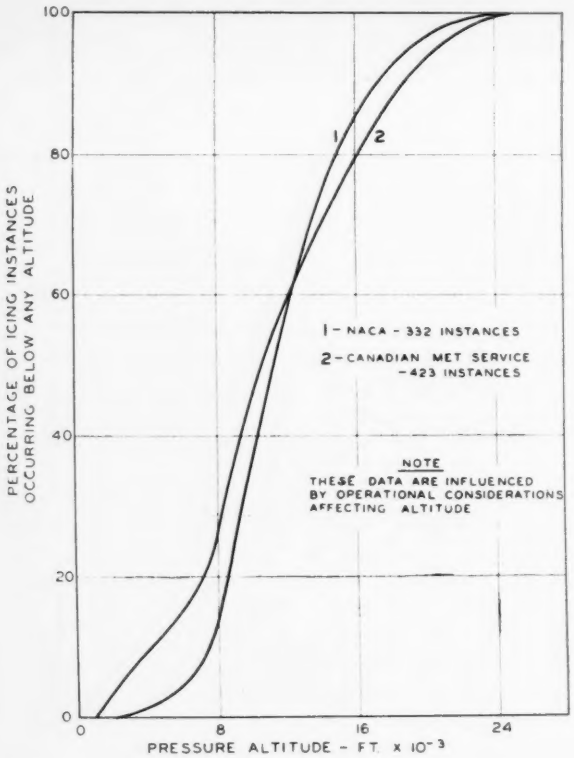


FIG. 7. Frequency of occurrence of icing below any altitude.

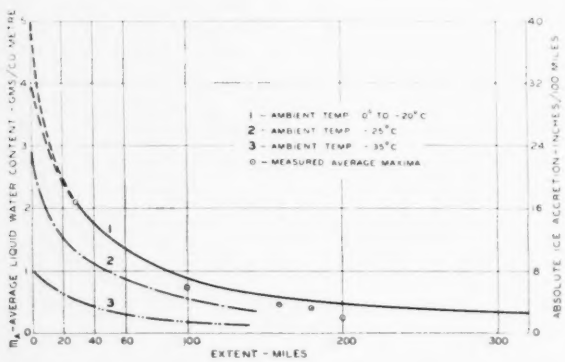

1 - AMBIENT TEMP. 0° TO -20°C
2 - AMBIENT TEMP. -25°C
3 - AMBIENT TEMP. -35°C
θ - MEASURED AVERAGE MAXIMA
EXTENT - MILES
ABSOLUTE ICE ACCRETION - INCHES/100 MILES

FIG. 8a. Suggested form of m_a vs. extent requirements.

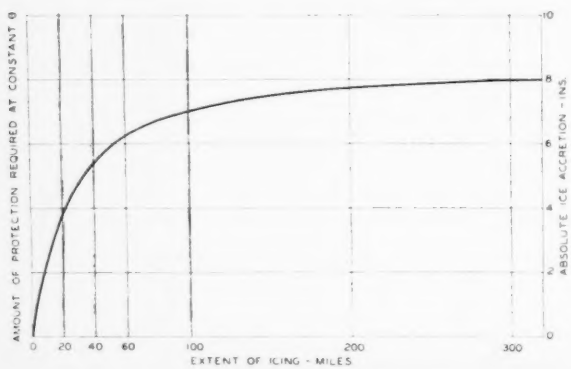


FIG. 8b. Alternative form of extent requirements.

(6) Need for Further Measurements

While quantitative values have been broadly indicated on all the foregoing diagrams, the observations on which the figures are based are comparatively few in number and limited in scope. They are, in fact, drawn from some 600 N.A.C.A. and some 500 N.A.E. observations, largely obtained over the North American continental area. Their extrapolation to the Pacific, North Atlantic, or tropical areas may not be valid.

Before any generally acceptable design figures could be stated, it would be necessary to accumulate far more data on icing severity. This can be done on both an operational and a research basis, as in the case of gust statistics.

Operational Measurements

As many aircraft as possible, on a variety of routes, should be fitted with means of measuring icing severity at three levels of accuracy—namely, using flight recorders, which will give continuous measurements of time, air temperature, rate of icing (to give liquid water content), altitude, and air speed. Because of cost and labor, this can only be applied to a few aircraft on selected routes. Arrangements for doing this in Canada have been made by N.A.E., using a rate-of-icing indicator and an ice-tolerant thermometer with visual observation and using a simple method [see Section (8)] of assessing rate of icing semiquantitatively and taking temperature measurements from the ordinary aircraft thermometer. By these means it should be possible to cover all regular routes over all seasons of the year, but only within the normal operating range of altitudes and weather conditions.[9]

Research Measurements

There is thus a need for research measurements at future operating altitudes and in extreme weather, to fill in the gaps in the statistical data. Research measurements are also necessary to provide a better understanding of the general icing problems.

(7) Control of Icing Protection Flow

The use of maximum design flow under all icing conditions involves a severe and unnecessary economic penalty. Referring again to Fig. 8, it appears that the greatest average flow of protection required over, say, 300 miles would be only about 10 per cent of the maximum instantaneous requirement. Thus, even the coarsest system of regulating flow to suit the ambient icing conditions would effect considerable economies.

Control could be applied manually, depending purely on visual observation. This, however, cannot be used for engine or propeller protection, in addition to which it is extremely difficult for a pilot to decide when he has passed out of icing conditions if he is still in cloud below freezing temperature.

It is preferable, if manual control is used, to depend on instrument readings, but there is little question that fully automatic control is desirable.

Control of Anti-Icing

For anti-icing, it is necessary to consider both m and θ simultaneously. If these are measured directly, a rather complicated control system will be required to translate the measurements into terms of flow requirements. However, the icing severity can also be measured indirectly, and a simple system has been devised by N.A.E. which has proved effective in regulating the flow of alcohol spray protection. The principle of this scheme is also applicable to charge heating.

For the anti-icing portions of an electrothermal protection system, a temperature sensing control has proved practical for keeping leading edges just free of ice.[17]

Control of Deicing

Control of deicing systems involves two separate operations. The deicing process has to be kept inoperative until the required amount of ice has been collected, at which time deicing must be started; then the deicing process must be controlled, particularly in the case of electrothermal shedding, where any excess in the heating period causes runback.

The "off" or icing-up period depends on m, at a given speed, and can therefore be determined by measurement of rate of icing or ice accretion. An "off" period control has been applied experimentally by N.A.E. to a pneumatic deicing system. The "on" or "shedding" time for either electrothermal or mechanical systems depends on some as yet undetermined factors, of which θ is only one, and therefore apparently cannot be determined on the basis of icing severity measurements alone. Schemes for the control of "on" periods are still under consideration.

(8) Nephelometric Instruments

The need for both research and operational measurements and the regulation of protection can only be met by the provision of suitable instruments. As there is no end to the invention of icing instruments, only those in regular use or showing definite promise will be discussed.

Temperature Measurement

Temperature measurements are liable to errors due to icing, radiation, and "compression" ("kinetic") effects. Icing can be avoided by suitable protection, while radiation errors are made negligible by shielding and adequate ventilation.

Research Instruments.—Special and somewhat similar housings are used by N.A.C.A. and N.A.E. (Fig. 9). These do not avoid a compression effect, the correction for which is tedious. A vortex housing avoids compression effects but is not ice tolerant.[10]

Operational Instruments.—A standard Weston sunshield can be easily modified (Fig. 10) to minimize icing and wetting, although it is not ideal with regard to radiation shielding.

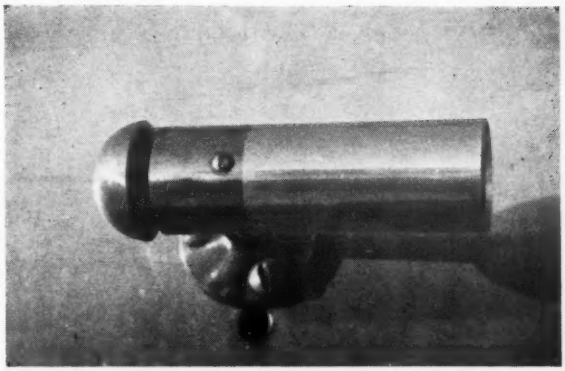


Fig. 9. N.A.E. ice-tolerant thermometer housing. Airflow →.

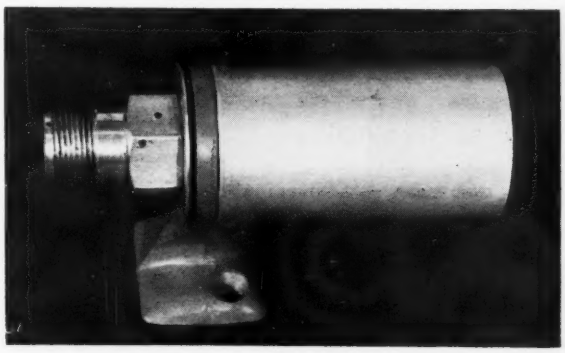


Fig. 10. Modified ice-tolerant Weston thermometer sunshield. Airflow →.

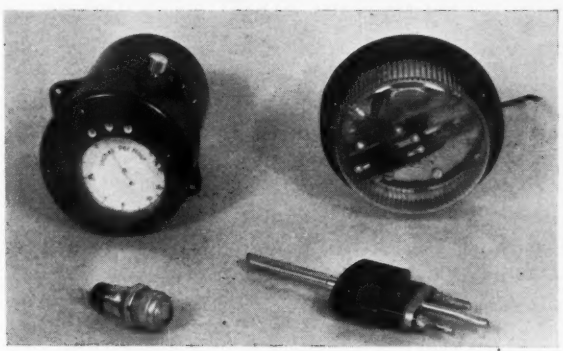


Fig. 11. Components of N.A.E.-Smith ice detector. (*Upper left*) Rate-of-icing indicator. (*Upper right*) Pressure switch. (*Lower left*) Indicator light. (*Lower right*) Detector head.

Measurement of Water Content

There are two standard methods of measuring free water content, neglecting hygrometric and light-scattering methods. The more common depends on measuring the rate of ice accretion on a cold body. There is, unfortunately, an upper limit to this rate, depending on temperature[11] and the type of instrument. This perhaps explains the gap in the m, θ data in the high water content-high temperature region. The second method is to determine the heat loss of a hot body exposed to the cloud. This method is non-selective between ice crystals and liquid water and has a widely separate calibration for each state.

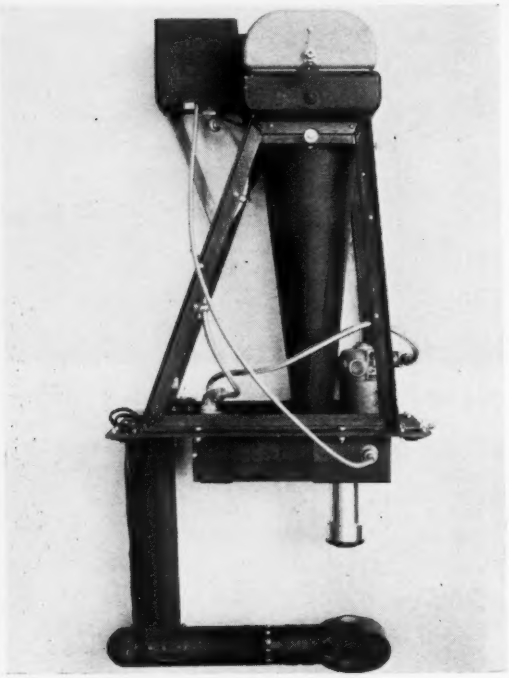


FIG. 12. N.A.E. cloud droplet camera.

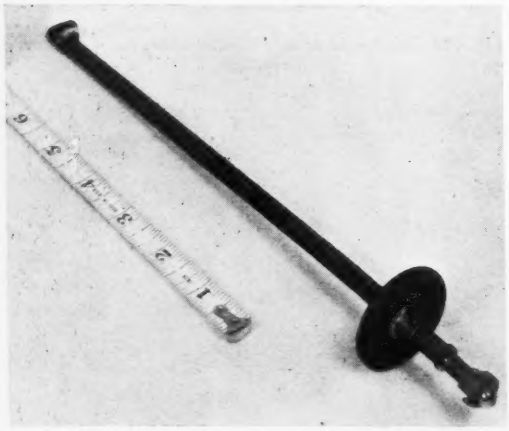


FIG. 13. N.A.E. hot-rod rate-of-icing indicator.

Research Instruments.—Rotating cylinders: These are inconvenient but give good results subject to a limiting rate of icing. The line *ZZ* on Fig. 3 shows approximately the limit of liquid water content that can be measured at 150 m.p.h., with a $^1/_8$ diameter cylinder. Rotating cylinders give only an average water content.

Rotating disc: This is a much more useful instrument, and is believed to have a higher rate-of-icing limit than rotating cylinders. This instrument gives a good indication of peak water contents.

R.A.E.-Sangamo-Weston ice detector: This measures the temperature difference between two hot wires, one of which is exposed and the other protected. It is nonselective between liquid and solid water and will have an indeterminate error in a mixed cloud.

Operational Instruments.—The Sangamo-Weston ice detector would have only a limited use as an operational instrument because of its nonselective behavior. The other known suitable instruments are as follows:

N.A.E.-Smith ice detector (Fig. 11):[13] This instrument depends on the blockage of pressure orifices by icing. It can be made to record or to give a visual rate-of-icing indication. It is subject to an upper limitation of about the same order as for the rotating cylinders. The N.A.C.A. pressure-type rate-of-icing meter works on a similar principle.[12]

N.A.E. Hot Rod (Fig. 13): This is merely a standard size of fixed cylinder. The time taken for, say, $^1/_4$ in. of ice to accrete is visually observed, and the rod is then deiced electrothermally.

Unfortunately, no certain method of calibrating any of the above water content instruments has yet been devised.

Droplet Size

Droplet size can be determined directly by the photography of undisturbed or trapped droplets or indirectly by relative catch efficiency or scattering of light.

Research Instruments.—Cloud droplet camera: This was developed by N.A.E. (Fig. 12)[14] and is also used by N.A.C.A.[15] These cameras photograph the undisturbed cloud particles but take only a small sample.

Oiled slide or film:[16] The particles are trapped on an oiled slide or continuously moving film and then photographed under a microscope. This technique is attractive but has unknown limitations at high speeds.

Rotating cylinders: Comparison of rates of accretion on cylinders of different diameters gives a theoretical drop-size distribution. This method is open to question.

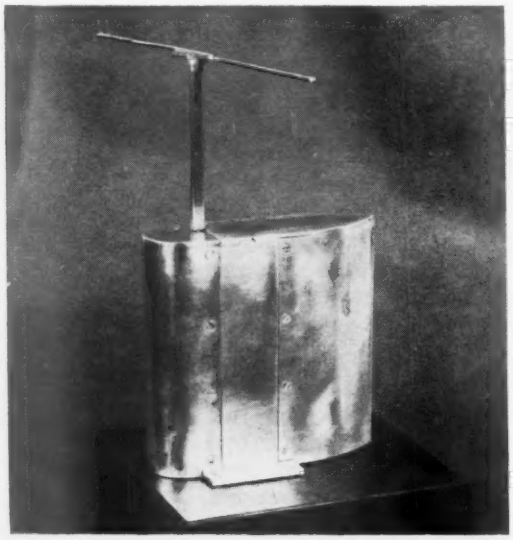


FIG. 14. N.A.E. MKII icing drag meter.

TABLE 1

Effect of Icing Severity Parameters on Icing Protection Systems
At given scale and velocity of aircraft. (First-order effects in CAPITALS; second-order effects in lower case.)

Icing Protection System		Severity Parameters			
		Air temperature	Liquid water content	Droplet size	Pressure altitude
Anti-icing	Thermal*	FLOW (of heat)	FLOW	COVERAGE Flow†	Flow
	Alcohol spray	FLOW (of liquid)	FLOW	COVERAGE	Flow
	Charge	FLOW	Flow	COVERAGE	Flow
	Heating	(of heat)			
Deicing	Electrothermal*	FLOW (shedding time)	FLOW (icing-up time)	COVERAGE Flow	...
	Mechanical	COVERAGE	Coverage	COVERAGE	
		COVERAGE	FLOW (icing-up time) Coverage	Flow	?

* The N.A.E. electrothermal deicing system is partially anti-icing and partially deicing.
† Droplet size affects flow because of its effect on catch.

Cloud density meter: The scattering of light from a chopped light source is measured by a photoelectric cell. Droplet size can be derived if free water content is known.

Operational Instruments.—None of the above methods is suitable for operational use.

Instruments for the Control of Protective Systems

Ice Detectors.—The importance of having a reliable and sensitive ice detector to warn the pilot, and to turn on protection automatically can hardly be overstressed. An ice detector must be selective not only to avoid wasting protection on nonicing conditions but also because of the excessive penalties of using thermal anti-icing in ice-crystal conditions.[17] The only ice-detector known to us which combines reliability, simplicity, and lightness is the N.A.E.-Smith ice detector, although its sensitivity may possibly be insufficient for some forms of ice protection.

Ice Accretion Meters.—It is desirable to have an ice-accretion increment, rather than a time increment, between cycles on a deicing system. The number of signals received from an orifice-type rate-of-icing meter is a fair indication of the total ice accretion. Any errors involved are not considered to be of great importance in the light of the limited present experience. The instrument can also be used in a special application for the control of alcohol spray protection. In extreme conditions the upper limit to the rate of icing may be a defect.

Drag Accretion Meters.—It is probably more refined, because of considerations of the overall economy of the aircraft, to determine deicing cycles in terms of an icing-drag increment. The N.A.E. drag accretion meter (Fig. 14) measures the difference in drag between a cold and a heated wire. When the drag reaches a preset amount, the cold wire is deiced and the cycle is repeated. Its period can be adjusted to correspond with the deicing period. This instrument also has a rate-of-icing upper limit.

(9) CONCLUSIONS

Icing parameters can be divided into a "severity" group, which affects the design, and a "distribution" group, which is of operational significance.

Design requirements are largely dependent on the liquid water content, m, and the temperature below freezing, θ, which determine the necessary flow of icing protection, and on droplet size, which largely determines coverage. Design requirements can thus be presented in a fairly simple form.

A method can be devised for assessing any new or existing protective system in terms of the statistical probability of encountering icing severities that exceed the capabilities of the system.

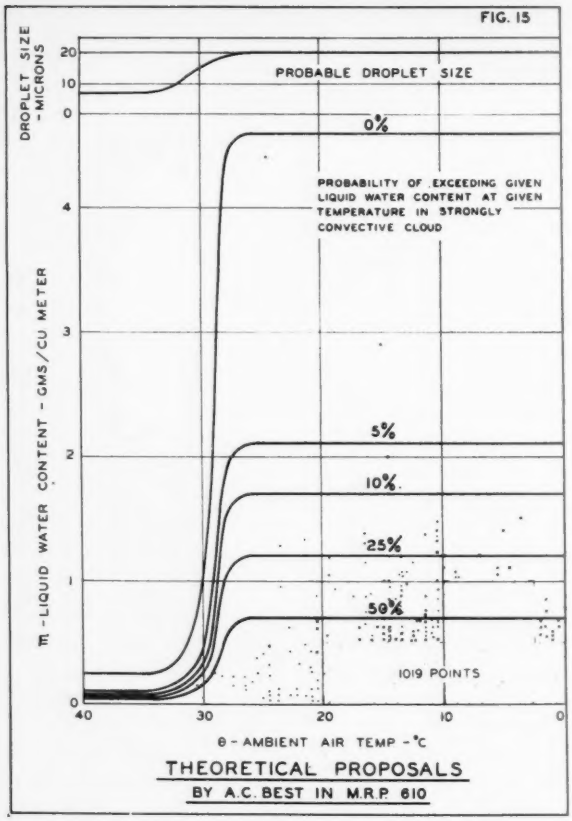
Statistical icing data can also be used to indicate the additional fuel or the alcohol which must be carried to provide icing protection.

There is insufficient statistical data, as yet, for the definite determination of design or operational requirements, and further measurements of icing severity, on both an operational and a research basis, are required.

By regulating the flow of protection to suit the ambient icing severity instead of using maximum design flow, considerable economies can be effected. It is probably necessary to base such regulation on measurements of icing severity.

Suitable instruments exist for the collection of both research and statistical icing data and for the regulation of icing protection flow, although the limitations of these instruments must be recognized.

Finally, it is recognized that this paper is incomplete and does little more than introduce its subject matter. Further studies of meteorological conditions and of the characteristics of ice protection schemes, patient and determined harvesting of icing data, further development of instruments and controls—all these are required before a clear and balanced definition of icing requirements can be reached and a common sense attitude to the icing problem can be attained.



Appendix (I)—Probability of Exceeding a Given Liquid Water Content at a Given Temperature in a Convective Cloud

Since completing this present paper, the authors have studied a most valuable paper of the Meteorological Research Committee (London), M.R.P. No. 610, by A. C. Best.

A method of computing the amount of liquid water in clouds with high base temperatures is used. After taking account of the variation with drop diameter of the temperature of spontaneous freezing of small drops, the probability of an aircraft encountering various concentrations of supercooled liquid water in strongly convective cloud in low latitudes is assessed (Fig. 15).

The correlation between the shape of the calculated curves and the distribution of the measured points is good.

Using this figure, instantaneous flow requirements for icing protection can be stated on a statistical basis, independent of the type of icing protection considered.

Thus a given icing protection flow could be assessed by the percentage requirement which it met, according to this type of figure.

In most cases the results given by this approach would be widely different from the assessment obtained by the methods suggested in section 4 of this present paper.

References

[1] Lewis and Hoecker, *Icing Conditions Encountered in Flight During 1948*, N.A.C.A. T.N. No. 1904, 1949.

[2] Kline, Dwight, and Steinmetz, *Further Investigations of the Meteorological Conditions Conducive to Icing*, N.A.C.A. T.N. No. 1424, 1947.

[3] Kline, *Investigations of Meteorological Conditions Associated with Aircraft Icing in Layer-Type Clouds for 1947–48 Winter*, N.A.C.A. T.N. No. 1793, 1949.

[4] Kline and Walker, *Meteorological Analysis of Icing Conditions Encountered in Low Altitude Stratiform Clouds*, N.A.C.A. T.N. No. 2306, 1951.

[5] Lewis, *Flight Investigation of the Meteorological Conditions Conducive to the Formation of Ice on Airplanes*, N.A.C.A. T.N. No. 1393, 1947.

[6] Perkins and Kline, *Analysis of Meteorological Data Obtained During Flight in Supercooled Stratiform Cloud of High Liquid Water Content*, N.A.C.A. R.M. E51D18, 1951.

[7] Pettit, *The Rockcliffe Ice Wagon and Its Role in Canadian Icing Research*, Royal Met. Soc. (Canadian Branch), 1951.

[8] McTaggart-Cowan, *Preliminary Report on Various Factors Affecting the Regularity of Transatlantic Services*, Met. Service of Canada.

[9] Fraser, *Learning More About Aircraft Icing*, Quarterly Bulletin, Nat. Aero. Est., N.A.E. 1951 (3), 1951.

[10] Fraser, *Measurement of Ambient Temperature in Icing Cloud—Qualitative Icing Tunnel Tests*, N.A.E. Note, unpublished, 1951.

[11] Ludlam, *The Heat Economy of Rimed Cylinder*, Quarterly Journal, Royal Met. Soc., Vol. 77, No. 334, 1951.

[12] Perkins, McCullough, and Lewis, *A Simplified Instrument for Recording and Indicating Frequency and Intensity of Icing Conditions Encountered in Flight*, N.A.C.A. R.M. E.51E16, 1951.

[13] Fraser, *Orifice-Type Ice Detector; Preliminary Icing-Tunnel Tests*, N.A.E. LR-3, 1951.

[14] Pettit, *Nephelometric Instrumentation for Aircraft Icing Research*, N.R.C. MD-33, 1950.

[15] McCullough and Perkins, *Flight camera for photographing cloud droplets in natural suspension in the atmosphere*, N.A.C.A. R.M. E50K01, 1951.

[16] Golitzine, *Method for Measuring the Size of Water Droplets in Clouds, Fogs and Sprays*, N.R.C. ME-177, 1950.

[17] Orr, Rush, and Milsum, *Electro-Thermal Methods of Aircraft Icing Protection*, N.A.E., 1951.

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

The Effects on Dynamic Lateral Stability and Controllability of Large Artificial Variations in the Rotary Stability Derivatives

By

Robert O. Schade, Ordway B. Gates, Jr., and James L. Hassell, Jr.

Langley Aero. Lab. N.A.C.A.

This paper presents the results of a theoretical and experimental investigation of the effects of large artificial variations of several stability derivatives on dynamic lateral stability and controllability. The derivatives considered were the yawing-moment-due-to-yawing velocity C_{n_r}, the rolling-moment-due-to-rolling velocity C_{l_p}, the yawing-moment-due-to-rolling velocity C_{n_p}, the rolling-moment-due-to-yawing velocity C_{l_r}, and the yawing-moment-due-to-rolling acceleration $C_{n_{\dot{p}}}$. Although the results do not apply directly to airplanes or flight conditions other than the two herein investigated, it is believed that the trends obtained might give an indication of the general effects of artificial stabilizing devices that cause changes in these derivatives. It was found that increases in oscillatory stability could be obtained by changes in any of the derivatives, but in some cases these increases in oscillatory stability were accompanied by detrimental effects on controllability and on the stability of the aperiodic modes. It appears from the results that the simultaneous change in two of the derivatives might be more satisfactory than a change in a single derivative for improving the damping of the oscillation without impairing the other flight characteristics.

Preprint No. 350

Prediction of Yawing Stability Characteristics of Airplanes During Catapulting

By

Henry J. Kelley

Grumman Aircraft Engineering Corporation

This paper presents the results of a theoretical investigation of the yawing behavior of an airplane during catapulting. The equations of motion of the airplane are developed, linearized, and solved approximately under reasonable physical assumptions. The analysis is based in part on previous work of Stevens.

For the relatively simple case where the tail (or nose) wheel is permitted to caster freely, the equations of motion are solved explicitly in terms of power series developments. In the more complicated (nonlinear) case involving a locked and skidding tail (or nose) wheel, the equations are solved by means of a finite difference procedure. Under further simplifying assumptions, a stability criterion is derived whereby a qualitative prediction of the stability of the airplane can be made, and trends as parameters are varied can be examined. A significant effect is that, as the tires become more flexible, the stability of the system improves.

Although the major portion of the paper is concerned with the single pendant towing arrangement, the case of the V-bridle has also been considered in some detail. A nonslipping bridle results in an extremely stable system, but an unfortunate arrangement combined with large misalignments can result in slipping and possible instability. A finite difference solution is necessary in the analysis of such a case.

A comparison is shown between calculations and a dynamically similar model typifying current jet fighter parameter.

A Review of Certain Analysis Methods for Swept-Wing Structures

By

M. L. Williams, Jr.

California Institute of Technology

Several proposed methods for swept-wing static structural analysis are reviewed with the aim of consolidating the knowledge currently available to the structural engineer faced with the problem of a swept-wing aircraft or missile design. In addition a fairly comprehensive bibliography on swept-wing analysis is included.

Three common types of construction—stiffened sheet, solid, and thick-walled shell structures—are discussed with respect to exact and approximate solutions for deflections and stresses. The main analytical deficiencies lie in evaluating the effect of wing-support conditions, particularly for the thick-skin wing.

It is concluded that, if the structure is specified and is one of the above three types, it can in most cases be analyzed by applying or extending analysis methods now available. Nevertheless, important work yet remains to be accomplished in the field of comparative design before the optimum swept-wing structure itself can be specified.

Preprint No. 374

Please do not order Preprints of these papers at this time.
See page 53 for Preprints that are immediately available.

A Solution of the Laminar Boundary-Layer Equations for a Compressible Fluid with Variable Properties Including Dissociation

By

L. L. Moore

The RAND Corporation

The laminar boundary-layer equations are solved for a flat plate in compressible flow where equilibrium dissociation of the air is assumed as well as variable air properties. Evaluation of the skin-friction and heat-transfer characteristics is made for a Mach Number range 1 to 20. Both the insulated plate without radiation and the plate with heat transfer are considered.

The nonlinear partial differential equations, having been reduced to five first-order ordinary equations in integral form, are solved by the differential analyzer, which is ideal for handling nonlinear relations as well as having the facility for absorbing graphical air property data.

Values of the physical and thermodynamic properties of air expressed in the quantities Pr (Prandtl Number), $\rho\mu/(\rho_B\mu_B)$ (density-viscosity parameter), and j (enthalpy parameter) are obtained from

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experimental data for lower temperatures and with the aid of the kinetic theory at the higher temperatures. Equilibrium dissociation produces an appreciable change in composition of air at the higher temperature thus introducing into enthalpy the heat of formation of dissociated products as well as altering the viscosity, Prandtl Number, etc.

Values of local skin-friction coefficient, c_f, and heat-transfer coefficient, h_c, are computed for the plate with heat transfer from the solutions of the boundary-layer equations assuming dissociation. Insulated plate temperature, T_i, and skin-friction coefficient for the insulated plate are likewise computed. Comparisons are made of these quantities with the values computed by others for no dissociation. The comparisons show that for heat transfer to the plate, c_f, and heat transmission per unit area $Q\ [= h_c(T_i - T_w)]$ are essentially unaffected by dissociation for plate temperatures in the range 400° to 2,500°R. The friction coefficient, c_f, for the insulated plate is unaffected by dissociation also. However, there is an apparent decrease in insulated plate temperature, T_i, with a corresponding increase in h_c due to dissociation both varying with ambient pressure. For very high plate temperatures—i.e., $j_w = 25$—dissociation affects Q greatly and the skin friction to a lesser extent. All computations are based on a temperature outside of the boundary layer, $T_\delta = 400°R$. In conclusion, the criterion for dissociation affecting the skin-friction and heat-transmission parameters is shown to be the presence of high temperature at the plate which causes dissociation at that location although the skin friction for the insulated plate is an exception to this rule.

Whirling of a Bladed Disc

By
John L. Bogdanoff
Purdue University

Whirling of a bladed disc mounted on a cantilever shaft is discussed, assuming the elastic blades have a highly idealized form. Results show that whirling cannot take place, except under restricted conditions, if the shaft possesses symmetrical elastic properties. When whirling can occur, blade flexibility has an appreciable effect on some of the whirling velocities.

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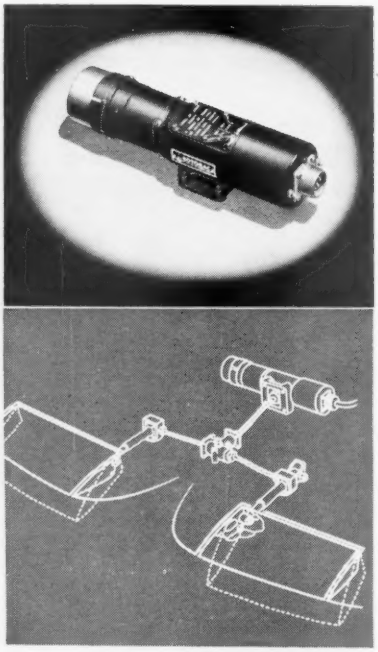
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George T. Hayes (T.M.), Head, Eastern Office, Industrial Economics Group, Stanford Research Institute, Washington, D.C. Formerly, with Stanford Research Institute, Calif.

Jack Hope (T.M.), Technical Engineer, Aircraft Nuclear Propulsion Project, General Electric Company. Formerly, Test Engineer, Thomson Laboratory, General Electric Company.

Bennett H. Horchler (A.M.), Assistant Publisher, *Skyways*, J. Fred Henry Publications. Formerly, Advertising Director, *Skyways*.

Bernard F. Jaeger (M.), Head, Aerodynamics Branch, U.S. Naval Ordnance Test Station, Inyokern, Calif. Formerly, Head, Experimental Research Section, Aerodynamics Branch, U.S. Naval Ordnance Test Station, Inyokern.

Robert J. Lang (M.), Contract Administrator, Western Sky Industries. Formerly, Chief Engineer, Aircraft Engineering and Maintenance Company and Transocean Air Lines.

Edward C. Light (M.), Vice-President in Charge of Engineering, Summers Gyroscope Company. Formerly, Chief Engineer, Summers.

Conrad F. H. Nagel, Jr. (A.F.), Vice-President, Aluminum Company of America. Formerly, Chief Metallurgist, Alcoa.

Robert G. Porter (M.), Research Engineer, Project Meteor, Massachusetts Institute of Technology. Formerly, Guided Missile Design Engineer, Army Ordnance Corps, Washington, D.C.

Robert J. Reed (T.M.), Editor, *Aviation Age*. Formerly, Western Manager, Chicago Office, *Aviation Age*.

Lieutenant (j.g.) Philip K. Roberts, U.S.N. (T.M.), Combat Information Center School, BOQ 56, Box 6, Naval Air Station, Glenview, Ill. Formerly, Flight Test Instrumentation Engineer, Chance Vought Aircraft Division, United Aircraft Corporation.

Ascher H. Shapiro (M.), Professor, Department of Mechanical Engineering, Massachusetts Institute of Technology. Formerly, Associate Professor, Department of Mechanical Engineering, M.I.T.

Richard E. Stockwell (A.M.), Editor, *The Monsanto Magazine*, Monsanto Chemical Company. Formerly, Editor, *Aviation Age*.

James A. Tremills (T.M.), Engineer "C," Canadair, Ltd. Formerly, Resident Engineer, Department of Public Works, Newfoundland, Canada.

Earl R. Walters (T.M.), now Electromechanical Engineer, The Glenn L. Martin Company.

Herbert K. Weiss (A.F.), Chief, Ordnance Engineering Laboratory, Ballistic Research Laboratories, Army Ordnance Corps, Aberdeen Proving Ground, Md. Formerly, Chief, Weapons Effectiveness Branch, Terminal Ballistic Laboratory, Aberdeen.

A. J. Wittenbach, Jr. (T.M.), Design Engineer, Selb Manufacturing Company. Formerly, Test Engineer, McDonnell Aircraft Corporation.

Arnold A. Zachow (M.), Vice-President—Engineering Sales, Ansley Radio & Television Company. Formerly, Bell Aircraft Corporation.

Necrology

Joseph S. Newell

Professor Joseph Shipley Newell, of Massachusetts Institute of Technology, died on May 5 in a Boston hospital after an illness of 2 days.

Born in Springfield, Mass., on August 10, 1897, Professor Newell was graduated from M.I.T. in 1919 with a Bachelor of Science degree in Civil Engineering, granted jointly by M.I.T. and Harvard. Immediately after his graduation, he went to Argentina, S.A., where he was employed as a Draftsman by Frigorifico Armour de La Plata. The following spring, he joined the staff at M.I.T. as Assistant to the Head of the Department of Civil Engineering. Among his duties at this time was instructing a course in Surveying.

In the fall of 1921, Professor Newell became a Junior Engineer with the State of Illinois' Highway Department. Early the following year, he left there to accept a position with the Engineering Division, U.S. Army Air Corps, at McCook Field, Dayton, Ohio. Through this last move he entered the aeronautical industry, and, from 1922 until 1927, he served in the Structures Unit, first, as Junior Engineer and, later, as Assistant Engineer. During this period, he was working on aircraft structural analysis, design, and research.

In 1927, Professor Newell returned to M.I.T. in the capacity of Instructor and during the following years was promoted successively to Assistant Professor, Associate Professor, and Professor of Aeronautical Structural Engineering. In 1946, he was appointed Executive Officer of the Department of Aeronautical Engineering and Secretary of the Faculty.

A Founder Member and Fellow of the Institute of the Aeronautical Sciences, Professor Newell was a member for many years of the I.A.S. Editorial Committee on Structures and Materials. During the past 3 decades, he wrote many papers on aeronautical structures which have been published in various technical journals. Among his works is a textbook entitled *Aircraft Structures*, which he co-authored with Prof. A. S. Niles.

Professor Newell is survived by his wife, the former Lena M. Dwelley, and four children, Joseph S., Jr., Naomi, Frederick D., and Charles W., of Lincoln, Mass.

William G. Thelander

William Gordon Thelander, T.M.-I.A.S., 21, was killed in an automobile accident on November 22, 1951.

A native of Little Falls, Minn., Mr. Thelander attended Morton High School in Cicero, Ill. After attending Morton Junior College for a year, he entered Purdue University, from which he was graduated with a B.S. degree in Aeronautical Engineering in January, 1951.

For the 6 months following graduation, Mr. Thelander was employed at Wright-Patterson Air Force Base and was responsible for the approval or disapproval of stress analysis reports submitted by the various companies. In July, 1951, he joined the staff of North American Aviation, Inc., in Los Angeles, as Stress Analyst, a position that he held at the time of his death.

American Helicopter Society News

Report of Eighth Annual Forum

A.H.S. Presidents—Incoming and Outgoing

Standing in front of the Collier Trophy for 1950, Bartram Kelley, of Bell Aircraft Corporation, A.H.S. Past-President (left), congratulates the incoming A.H.S. President, T. R. Pierpoint, of Piasecki Helicopter Corporation.

Indicative of the continuing growth of the helicopter industry over the past year, approximately 450 military and industry personnel enrolled at the American Helicopter Society's Eighth Annual Forum held in Washington on May 15–18. Registration for the 1951 forum was 350 members.

Under the chairmanship of H. S. Tremper, the forum included 2 days of technical sessions, at which 17 papers were presented on helicopter developments and operations. The first day's activities were climaxed by the Honors Night Banquet, held in the Hall of Nations Room of the Hotel Washington. The Honorable Frank Pace, Jr., Secretary of the Army, was guest speaker, following presentation of the Society's four annual awards and honors. Friday evening the annual Pioneers Night stag dinner was held at the National Press Club.

Helicopters were scheduled to play an active part in the Armed Forces Day Air Show and Static Display at Bolling Air Force Base on May 17th and 18th. However, the oil strike necessitated cancellation of flight demonstrations and, as a result, only a few of the helicopters now in service were on static display. These were, perhaps significantly, displayed with other aircraft in the same branch of service, rather than set apart in a separate exhibit.

Technical Sessions

Charles W. Lefever, Technical Chairman, headed the 2 days of technical sessions held in the Hall of Nations Room at the Hotel Washington.

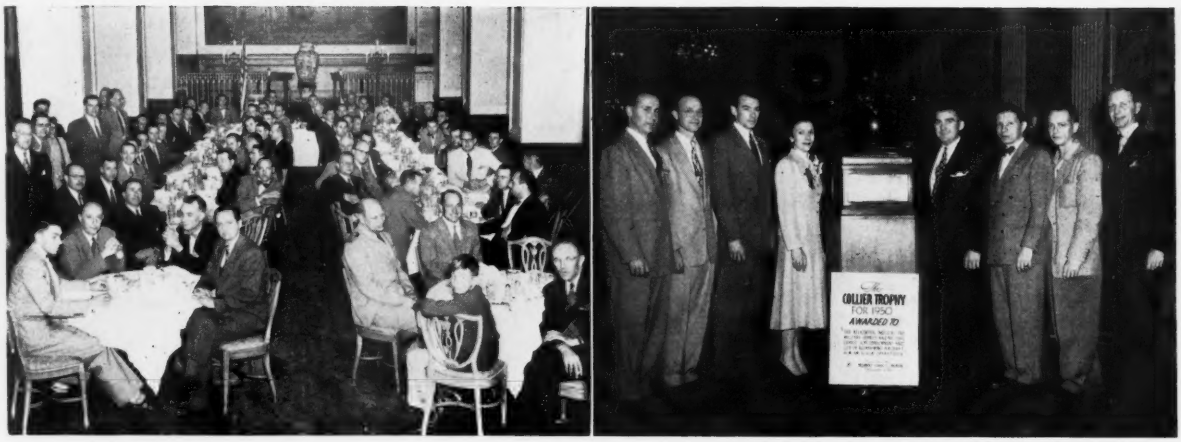
The first day included presentation of papers on Theory and Design and Development and Test. Captain Paul A. Simmons, U.S.A.F., Propeller Laboratory, A.M.C. and Raymond A. Young, Research Division, Navy BuAer, acted as Chairmen for the respective sessions. The May 16 sessions on Maintenance Operations and Flight Operations were chairmanned by T. R. Pierpoint, Service Manager, Piasecki Helicopter Corporation, and Joseph Mashman, Assistant Manager of Contracts, Bell Aircraft, respectively. Subjects of the papers presented at these sessions were:

Theory and Design

"Comparison of Helicopter Rotor Propulsion Systems," by Joseph Stuart, III, Bell Aircraft Corporation.

A.H.S. Award Winners and Honors Night Speaker

Left—A.H.S. Honors Night award winners stand with the Awards Chairman, Frank N. Piasecki. Standing from left to right are: Bernard L. Whelan, recipient of one of the society's Honorary Fellowships; Col. Jack L. Marinelli, U.S.A., who accepted the Capt. William J. Kossler Award in behalf of the U.S. Army Field Forces; Mr. Piasecki; Col. Paul A. Charbonneaux, who accepted the Dr. Alexander Klemin Award on behalf of Louis Breguet; and Harvey Gaylord, who accepted the Honorary Fellowship on behalf of Lawrence D. Bell. Right—Secretary of the Army Frank Pace, Jr., is shown as he completes his address to the members and guests of the American Helicopter Society's Honors Night Banquet.



A.H.S. Membership Luncheon and Newly Elected Officers

Left—A.H.S. members are shown during the First Annual Membership Luncheon of the American Helicopter Society. Right—The newly elected A.H.S. officers for the coming year are, from left to right: Regional Vice-President—Middle Atlantic, Charles W. Lefever; Regional Vice-President—New England, Miller Wachs; Regional Vice-President—Southeastern, Ray Young; Jean R. Howard, Secretary; T. R. Pierpoint, President; Monroe R. Brown, Treasurer; Regional Vice-President—West Coast, Robert Wagner; and Regional Vice-President—Midwest, Charles R. Wood. Not included in the picture is John Beadling, Regional Vice-President—Southwest. The 1950 Collier Trophy is shown between Miss Howard and Mr. Pierpoint. This trophy was awarded to "The helicopter industry, the military services, and Coast Guard for development and use of rotary-wing aircraft for air-rescue operations."

"Some Remarks on Dynamic Stability of the Helicopter and Characteristics of Gyratory Stabilizing Systems," by Dr. G. J. Sissingh, Chief of Aerodynamics, Kellett Aircraft Corporation.

"Helicopter Turbine Powerplant Development" by J. O. Emmerson, Chief Engineer, The Kaman Aircraft Corporation.

"The Effect of Blade Mass Constant and Flapping Hinge Offset on Maximum Blade Angles of Attack at High Advance Ratios," by John R. Meyer, Jr., and Gaetano Falabella, Jr., Research Engineers, M.I.T.

"An Analysis of the Helicopter Transfer Function To Predict Achievable Handling Characteristics of the Stabilized Helicopter," by Edward Sterling Carter, Jr., Assistant Chief Vibration Engineer, Sikorsky Aircraft Division, United Aircraft Corporation.

Development and Test

"A Review of British Helicopter Developments," by A. McClements, A.R.T.C., M.I.Mech.E., Honorary Technical Editor of The Helicopter Association of Great Britain. (Paper was read by L. Wigdortchik.)

"Some Aerodynamic and Dynamic Problems of the Compound Rotary-Fixed Wing Aircraft," by Kurt Hohenemser, Chief Aerodynamicist, Helicopter Engineering Division, McDonnell Aircraft Corporation.

"Development of High Lift Airfoils by Boundary Layer Control," by Kenneth Razak, University of Wichita.

"Air Force Testing and Evaluation of Helicopters," by Capt. Wayne W. Eggert, U.S.A.F., Wright Air Development Center, Wright-Patterson A.F.B.

Maintenance Operations

"Problems in Korean Helicopter Maintenance and Their Relations to the Service Representative," by Harold Nachlin, Service Representative, Sikorsky Aircraft Division, United Aircraft Corporation.

"Design for Maintenance," by Lt. P. W. Kerr, U.S.N. and Capt. E. J. Pope, U.S.M.C., Helicopter Maintenance Project Officers, Maintenance Division, Bureau of Aeronautics, U.S.N.

"U.S. Army Helicopter Maintenance Experience in Korea," by Lt. Col. G. L. Lovett, U.S. Army, Ordnance Corps.

"Air Navigation Development Board Program for Development of Aids for Helicopter Navigation and Traffic Control," by Lt. Col. W. M. Young, U.S. Army.

Flight Operations

"Role of Transport Helicopter in Metropolitan Areas," by Jack Rothman, Manager of Operations, New York Airways.

"Helicopter Operations in Alaska," by Lt. Col. Gene L. Douglas, U.S.A.F., Headquarters, Air Rescue Service, M.A.T.S.

"Helicopter Operation for Patrol of Power Lines in Remote Areas," by T. J. Burgess, Line Maintenance Engineer, Hydro Electric Power Commission of Ontario.

"Korean Rescue Operations," by Major John J. Dean, U.S.A.F., Air Rescue Service, M.A.T.S.

Printed copies of the Proceedings were available at the forum at $3.50 per copy for A.H.S. members. Copies may still be obtained by writing the American Helicopter Society, 2 East 64th Street, New York City.

Honors Night

Frank N. Piasecki, Awards Chairman, presented the Society's awards at the Honors Night Banquet.

The Dr. Alexander Klemin Trophy, highest honor awarded by the American Helicopter Society, was presented to Louis Breguet, French aircraft designer who built and flew his first helicopter in 1907 and has continued to be active in the rotary-wing field for the past 45 years. Colonel Paul A. Charbonneaux accepted the award in Mr. Breguet's behalf.

The Captain William J. Kossler Award was presented by Adm. Merlin O'Neill, Commandant of the U.S. Coast Guard (in which service Captain Kossler pioneered the use of helicopters), to the U.S. Army Field Forces in recognition of their developments that have made possible the Army's outstanding record in use of helicopters for evacuation work in Korea. Lieutenant Colonel Jack L. Marinelli, Chief of the Aviation Section, Headquarters, Army Field Forces, Fort Monroe, Va., accepted the award on behalf of the Army Field Forces.

The two honorary fellowships of the Society were conferred upon Lawrence D. Bell, President of Bell Aircraft, and Bernard L. Whelan, General Manager of the Sikorsky Aircraft Division, United Aircraft Corporation.

Following the awards, Secretary of the Army Frank Pace, Jr., spoke on "Air Mobility For the New Army," defining the important role the helicopter will

play in the Army's future plans to ensure a flexible defense.

In summarizing the important part helicopters have already played in troop mobility in the Korean combat areas, Secretary Pace said: "There is no doubt in my mind that, when the lessons of Korea have been fully assessed, the dependence of ground units on helicopters for observation, communication, control, and fire direction—as well as for transport—will emerge as one of the most important. And, from the Korean battleground, commanders continue their urgent requests to 'send more Army aircraft—especially helicopters.' "

Pioneers Night

Winding up the 2-day program, rotary-wing enthusiasts gathered at the National Press Club on Friday evening for the annual (stag) Pioneers Night Dinner. The completely informal program is being reported by word-of-mouth.

The First Annual Membership Luncheon

The First Annual A.H.S. Membership Luncheon, held on the second day of the Forum, was presided over by Chairman H. S. Tremper. The Society's new officers were introduced and a summary report of the A.H.S. activities was given by outgoing president Bartram Kelley.

T. R. Pierpoint, of Piasecki Helicopter Corporation, was introduced as the newly elected president of A.H.S. In addition, six regional vice-presidents also were recognized. They are: Miller Wachs, of Sikorsky Aircraft, New England; Charles W. Lefever, of Prewitt Aircraft Company, Middle Atlantic; Ray Young, of the Navy Bureau of Aeronautics, Southeastern; Charles R. Wood, of McDonnell Aircraft Corporation, Midwest; John Beadling, of Bell Aircraft Corporation, Southwest; and Robert Wagner, of McCulloch Motors Corporation, West Coast. Re-elected to office were: Monroe R. Brown, of Piasecki, treasurer; and Jean R. Howard, of the Aircraft Industries Association, secretary.

Mr. Kelley in reviewing the society's activities during the past year, reported that membership in the American Helicopter Society had increased about one hundred to a total of approximately 400 and that both the Seventh and Eighth Annual Forum papers were selling well.

During the 1951 forum, there were approximately 350 registrations, and it was estimated that 450 would be the total enrollment for the 1952 forum.

Seven regional meetings were held during the past year, nearly all of which where reported in the AERONAUTICAL ENGINEERING REVIEW, and papers were distributed free to A.H.S. members. Some of the papers presented were: "Maintenance Problems of Naval Helicopter Operations," by Lt. Comdr. John Armstrong; "C.A.A. Policy of Helicopter Flight Testing," by Harold H. Hermes; "A Tested Solution of the Problem of Helicopter Stability and Automatic Control," by Donald N. Meyers, Edward C. Vanderlip, and P. Halpert; "Results of Recent Rotor Blade De-Icing Tests on Mt. Washington," by Lieutenant Commander Houser and R. R. Lynn.

Mr. Kelley then reported on the new affiliation agreement with I.A.S. It was recently signed by A.H.S. and I.A.S. officers and extends for an additional 2-year period, ending May 1954. The present arrangement with the Institute will continue with the additional proviso that a manager will be employed by the I.A.S. to serve full time in handling American Helicopter Society work. This is a significant step forward for A.H.S.

In accepting his new position as President, Mr. Pierpoint stated that every effort will be made to forward one paper a month to members and to increase the local regional meetings.

Mr. Kelley then thanked the 1952 Forum Committee for the successful handling of the largest attended American Helicopter Society Annual Forum.

Committee Chairmen were: H. S. Tremper, Chairman, the Forum Committee; Charles W. Lefever, Technical Chairman; Frank N. Piasecki, Chairman, Honors Award Committee; John E. Beighle, Chairman, Dinner Committee; E. J. Odlum, Chairman, Air Show Committee; Claude O. Witze, Chairman, Publicity; and Jean Ross Howard, Chairman, Arrangements.

The Honors Award Committee was comprised of: Frank N. Piasecki, Chairman; Bartram Kelley, Alex McSurely, Herbert Toomey, Ralph Lightfoot, R. Allen Price and Paul Stanley.

PEG G. COALE
Assistant to the Publicity Chairman, A.H.S.

Corporate Member News

• **AiResearch Manufacturing Company, Division of The Garrett Corporation**...An integrated low-pressure pneumatic power system for today's high-altitude high-speed turbojet and turboprop aircraft was given its first public showing at the recent Society of Automotive Engineers' National Aeronautic Meeting.

• **American Airlines System**...Edmund O. Schroeder was elected Assistant Vice-President—Maintenance and, as such, is in charge of all day-to-day maintenance at the stations in the company's system. Mr. Schroeder, who was formerly American's Manager of Production Control, is based at Tulsa...Morris L. Rinehart was elected as Assistant Treasurer by American's Board of Directors.

• **American Bosch Corporation**...At a recent meeting of American Bosch's Board of Directors, Donald P. Hess, who has been serving as President of American Bosch and of its wholly owned subsidiary, Arma Corporation, resigned the position as President of Arma in order to devote his full time to American Bosch as its President. Accordingly, the Directors elected Arthur P. Davis as Arma's President and advanced Mr. Hess to Vice-Chairman of the subsidiary's Board of Directors.

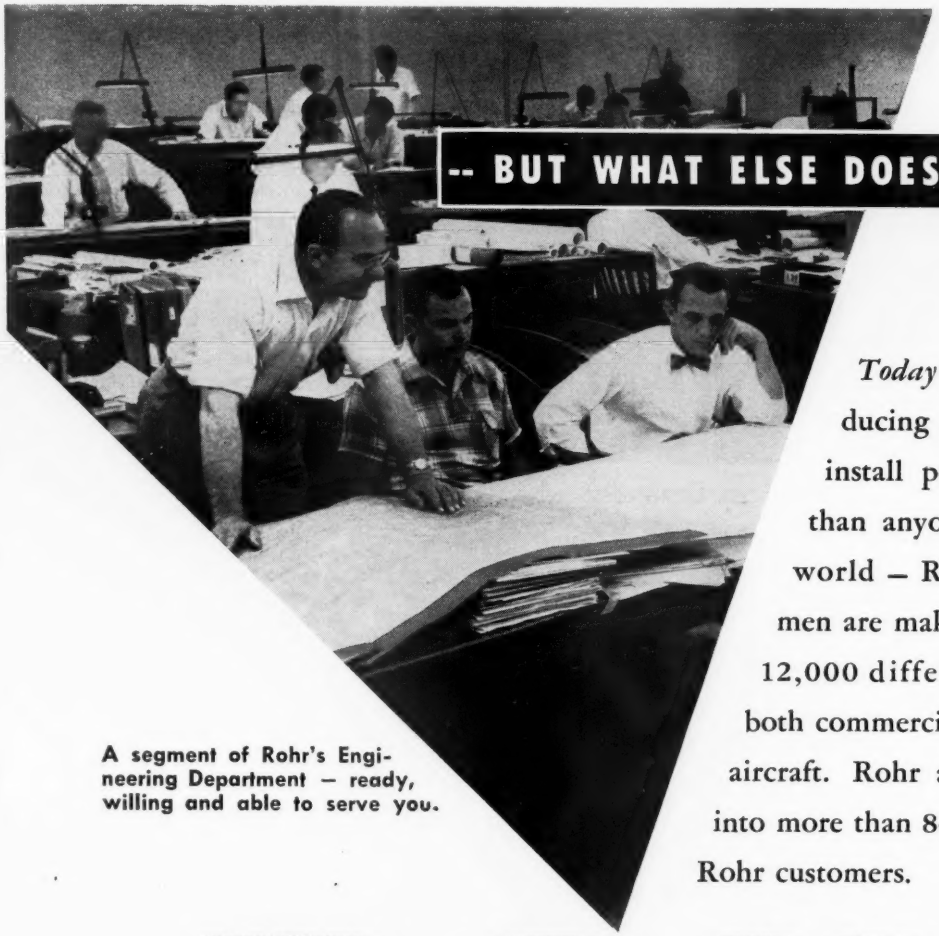
• **American Phenolic Corporation**...Two of American Phenolic's Vice-Presidents, Richard M. Purinton, who is Administrator of Engineering, and William H. Rous, who has been Sales Manager for many years, were elected to membership on the Corporation's Board of Directors.

• **American Steel & Wire Division, United States Steel Corporation**...Among the various products displayed at the recent National Aeronautic Meeting and Aircraft Display of the Society of Automotive Engineers was the new type of aircraft control cable, Hyco-Span. Hyco-Span is said to be nonmagnetic and, therefore, will not interfere with the operation of electronic equipment, radar, or navigation and communication facilities. Tests of Hyco-Span were conducted at the meeting to demonstrate not only the cable's nonmagnetic qualities, but also its service life under conditions of stress and its relatively high coefficient of expansion over normal corrosion-resistant and carbon steel control cables.

• **Bell Aircraft Corporation**...William G. Gisel was appointed Comptroller, and John W. Rane, Jr., was named an Assistant Secretary.

• **Boeing Airplane Company**...The normal combat range of the new six-jet Boeing B-47B Stratojet has been considerably increased over the earlier B-47's through the use of more powerful engines and the addition of the largest external fuel pods yet mounted on an airplane. The engines in question are the new General Electric J-47-23 power plants, each of which develops more than 5,800 lbs. of thrust. The huge streamlined fuel tanks, the capacity of which was not revealed, are being built to Boeing specifications by Ryan Aeronautical Corporation. They will be suspended, one under each wing, between the tip and the inboard jet-engine pods. The bomber itself is being produced at Douglas Aircraft Company's Tulsa Division and at Lockheed Aircraft Corporation's Georgia Division.

• **Canadair Ltd.**...An extensive design study of a local-service aircraft, known as the CL-21, has been completed. Cur-



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Today — besides producing more ready-to-install power packages than anyone else in the world — Rohr Aircraftsmen are making more than 12,000 different parts for both commercial and military aircraft. Rohr assembles these into more than 840 products for Rohr customers.

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OF READY-TO-INSTALL POWER PACKAGES
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in Chula Vista, California . . . 9 miles from San Diego

rently, the company is making a world-wide survey of sales potential on this particular design. The CL-21 is said to be a twin-engined high-wing 32-passenger transport, the selling price of which is estimated to be around $450,000.

• **Chase Aircraft Company, Inc.**... Clay P. Bedford has been elected President of the company. Mr. Bedford was formerly Executive Vice-President of Kaiser-Frazer Corporation.

• **Consolidated Vultee Aircraft Corporation**... The U.S.A.F. has ordered an undisclosed number of the new pressurized twin-engined C-131A transport planes. Designed especially for air evacuation operations, the ship will be equipped with 20 rearward-facing seats and 16 litters. If desired, the 16 litters can be replaced by an additional 20 seats. The C-131A is based on the design of the Convair-Liner 240.

• **Curtiss-Wright Corporation**... Lt. Gen. Levin H. Campbell, Jr., U.S.A. (Ret.), has been elected to the Board of Directors. General Campbell has been an Executive Vice-President of International Harvester Corporation.

• **Ethyl Corporation**... A new plant located on the Houston Ship Canal about 17 miles from Houston, Tex., has been put into operation. This plant, one of the largest of its kind, is producing "Ethyl" antiknock compound and is thereby increasing the corporation's manufacturing capacity by approximately one-third.

• **General Electric Company**... A new "slide-rule" with silhouettes and published information on the latest military aircraft has been devised by G-E's Aircraft Gas Turbine Division. On one side of the plastic data chart is a quick reference for information on air frames, operational data, and power plants of 42 aircraft. On the reverse side is Douglas Aircraft Company's air-speed vs. altitude chart. They are available in lots of 50 for $25 by addressing a request for GEN-60 to the company at Schenectady, N.Y.... A new eight-page selection guide for a wide range of electric and electronic controls, devices, and accessories has been announced. This bulletin, designated the GEA-5781, contains quick-reference selection data, photographs, and listings of additional publications that give complete information on each of the equipments.

ALCOA VICE-PRESIDENT

C. F. Nagel, Jr., A.F.I.A.S., was elected a Vice-President of Aluminum Company of America. This post is one of three such positions recently created at Alcoa, the other two being filled by Gordon W. Cameron, Treasurer since 1943, and Arthur P. Hall, formerly Director of Public Relations and Advertising. Mr. Nagel, who has been with Alcoa since his graduation from Cornell University in 1915, was formerly the company's Chief Metallurgist.

• **The B. F. Goodrich Company**... The company has announced the liquidation of its wholly owned subsidiary, American Anode, Inc., at the close of business on March 31, 1952. Effective on April 1, the business was carried on under the name of "American Anode, a Division of The B. F. Goodrich Company." No personnel changes were involved.

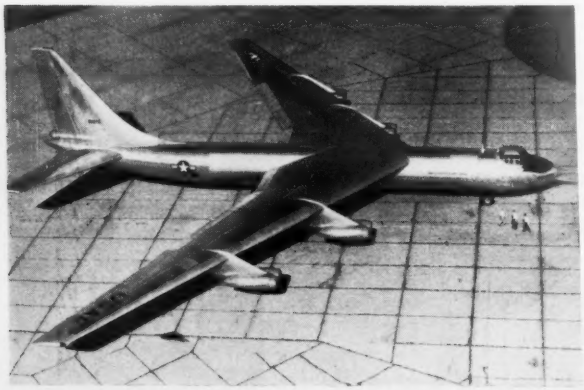
• **The International Nickel Company, Inc.**... Subsequent to the recent annual organization meeting of the Board of Directors, various executive changes were announced. Dr. Paul D. Merica, Executive Vice-President and a Director, was elected President of The International Nickel Company of Canada, Limited, and of its United States subsidiary, The International Nickel Company, Inc. Dr. Merica succeeds Dr. John F. Thompson who retired as President but who is continuing as Chairman of the Board and Chief Officer of the parent company and its U.S. subsidiary. R. Leslie Beattie, Vice-President and General Manager of the company's Canadian operations, was elected a member of the Executive Committee of the Board and a Director of the company's U.S. subsidiary. H. C. F. Mockridge, Q.C., of Toronto, was also elected to the Board's Executive Committee. J. R. Gordon, Assistant Vice-President, was appointed Assistant General Manager and will manage Canadian operations under Mr. Beattie's direction. Ralph D. Parker, Assistant Vice-President, became Vice-President and a Director of another subsidiary, Canadian Nickel Company Limited. William F. Kennedy was named Secretary of the company, succeeding Henry S. Wingate who is now devoting his full time as Vice-President and a Director of the company. Within The International Nickel Company, Inc., itself, Vice-President Walter C. Kerrigan was elected to the newly created position of Vice-President and General Sales Manager: L. R. Larson was elected Assistant Vice-President and Assistant General Sales Manager. Promoted to Assistant Vice-Presidents were Theodore H. Dauchy, Richard A. Cabell, and John A. Marsh.

• **Jack & Heintz, Inc.**... A pneumatic starter for turbojet and turboprop engines is being developed for the U.S.A.F.

• **Walter Kidde & Company, Inc.**... An associate organization, Walter Kidde

TWO EIGHT-JET ADDITIONS TO AMERICA'S AIR POWER

The YB-60 (left), a swept-wing all-jet development of Consolidated Vultee Aircraft Corporation's B-36, and the YB-52 (right), a progression of Boeing Airplane Company's B-47 design, are currently undergoing a series of flight tests. The YB-60 made its initial flight on April 18; the YB-52 took off on its maiden flight 3 days earlier. Each of these long-range bombers is powered by eight of the new J-57 axial-flow turbojet engines, produced by Pratt & Whitney Aircraft Division, United Aircraft Corporation, and believed to be the most powerful of their type now in use. The YB-60, according to recently released information, is somewhat larger than the YB-52. Specifically, the general dimensions of the bombers are: wing span—YB-60, 206 ft., and YB-52, 185 ft.; length—YB-60, 171 ft., and YB-52, 153 ft.; and tail height—YB-60, 50 ft., and YB-52, 48 ft.



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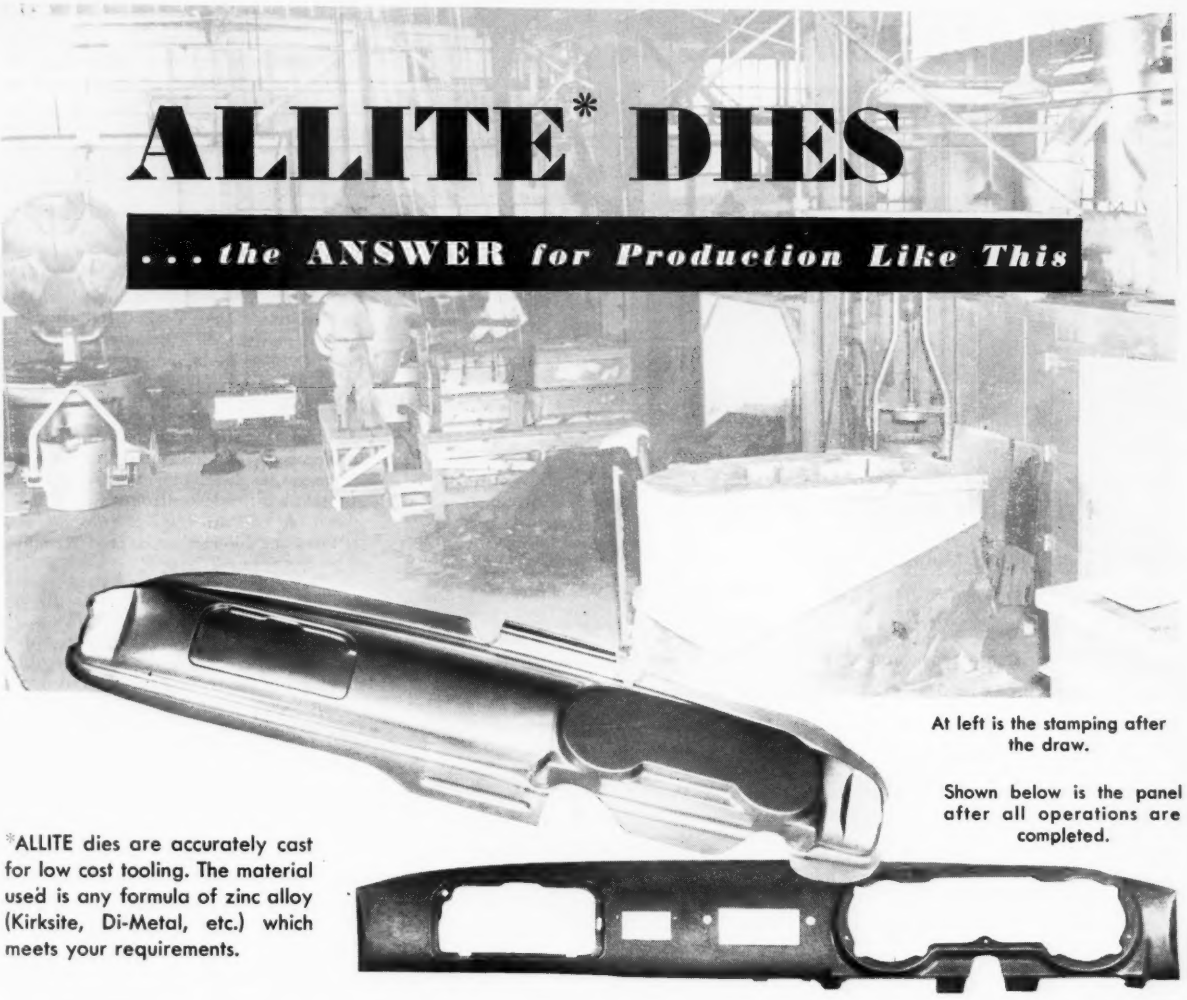

At left is the stamping after the draw.

Shown below is the panel after all operations are completed.

*ALLITE dies are accurately cast for low cost tooling. The material used is any formula of zinc alloy (Kirksite, Di-Metal, etc.) which meets your requirements.

Allite Dies were used as the tooling for this right-hand instrument panel. These were the results:

- **The tooling costs were less than half that which would have been required for iron dies.**
- **The customer reports that more than 8000 stampings have been produced, with the original Allite draw die still in serviceable condition. This die is 100% zinc alloy.**

This is typical of many Allite Die applications where all the advantages of low cost tooling, faster production starts and accurately built tools have been combined. And that has only been made possible by the close coordination of foundry and die shop facilities which only Allied can offer.

Allite Dies can be the answer to your experimental or short run production die problems, too. Why not write today for the complete story.

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PLANT 2
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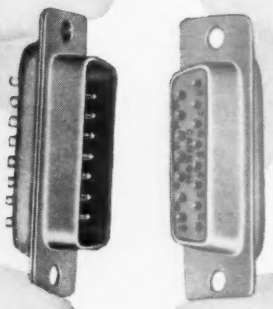
PLANT 4
Hillsdale, Mich.

the new sub-miniature

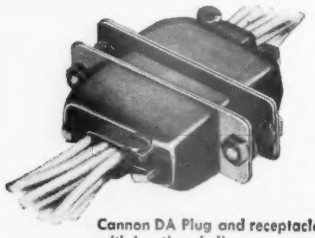
CANNON PLUGS



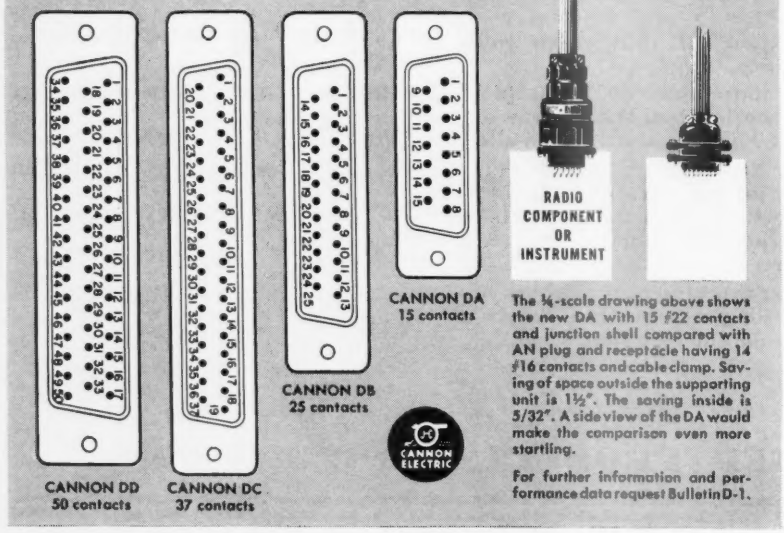
tiny but rugged

Series D Cannon Plugs satisfy a long felt need of the Electronics Industry for a sturdy, versatile and extremely compact connector for use on miniaturized equipment of all kinds. These may be mounted as (1) rack and panel (2) box (3) wall, or (4) cord connectors. Junction shells with integral clamps protect the terminal ends of the connector when used as cord or wall mounted units.

Contacts are of the quality you expect to find in any Cannon Plug. Machined from copper base alloy, gold plated, they accommodate #20 or #22 AWG stranded wire. Rated capacity 5 amps. High dielectric insulators. Minimum flashover, 1000 volts rms. The protective steel shells provide an integral mounting flange. The "keystone" shape of the shells gives positive polarization with friction type engagement.



Cannon DA Plug and receptacle with junction shells.



The ¼-scale drawing above shows the new DA with 15 #22 contacts and junction shell compared with AN plug and receptacle having 14 #16 contacts and cable clamp. Saving of space outside the supporting unit is 1½". The saving inside is 5/32". A side view of the DA would make the comparison even more startling.

For further information and performance data request Bulletin D-1.

CANNON ELECTRIC

SINCE 1915. Factories in Los Angeles, Toronto, New Haven, Benton Harbor. Representatives in principal cities. Address inquiries to Cannon Electric Company, Dept. G-105, P. O. Box 75, Lincoln Heights Station, Los Angeles 31, California.

Nuclear Laboratories, Inc., has been established to develop commercial atomic power. This privately financed laboratory will perform research, development, and experimentation in the field of nuclear energy. Services of the firm are available to other organizations interested in the design of nuclear power plants or in applications of nuclear technology to their products and processes. Technical activities are under the executive direction of Dr. Karl Cohen. The development and engineering work of Walter Kidde Nuclear Laboratories is being conducted at 140 Cedar Street, New York City, while the laboratory research is being carried out at facilities on Long Island.

• **Lear, Incorporated**... The LearCal Division has developed a modification of the Lear Orienter to be used by the military and to be known as the ADF-14. Among other developments at Lear is the automatic altitude control, which was designed for use with the L-2 Autopilot and to keep the aircraft at a predetermined altitude.

• **Lockheed Aircraft Corporation**... Wingtip fuel tanks, capable of holding 600 gals., are currently being tested on the Super Constellations. These wing tanks will be standard on the turboprop-powered Super Constellations on order for the U.S.N.... The assembly-line system of mounting each air frame on a separate dolly and rolling it along the floor has been replaced at Lockheed by an "elevated railway" production line. In this method, the front and rear of each fuselage section are attached to light-weight frames that roll on wheels along tracks raised several feet off the factory floor. One of the advantages of this system is that it permits a far more rapid shift of a line of fuselage structures from one station to another along the assembly line than is possible with the previously used dollies... A newly completed $3,160,000 factory-office building was dedicated on April 24. This 165,000-sq.ft. structure provides sufficient space to bring together under one roof more than half of Lockheed's 3,300 employees of the Engineering Division... D. J. Haughton, formerly Assistant General Manager of the Georgia Division, was named Vice-President and General Manager of that division. Mr. Haughton replaces James V. Carmichael who was elected a Director of the corporation.

• **The Glenn L. Martin Company**... The U.S.N.'s Atlantic Fleet Air Force took delivery last April 23 of the first 36-ton P5M-1 Marlin seaplane patrol bomber. The P5M-1 is designed and built primarily for antisubmarine warfare and is in itself a one airplane hunter-killer team.

• **McDonnell Aircraft Corporation**... James E. Webb, former Under Secretary of State, has been elected to McDonnell's Board of Directors.

• **The Parker Appliance Company**... A synthetic rubber compound, 1009–10, has been developed for O-rings and other molded seals. The company states that "the new material, with excellent low temperature characteristics, undergoes 20 per cent less volume change in the presence of hydrocarbon fuels than any material heretofore developed." It is said to be

particularly valuable for equipment designs subject to −65°F. qualification "where previously available compounds have been ruled out on the grounds of high swell." This synthetic rubber compound has a Shore A hardness of 70°, a tensile strength of 1,500 lbs. per sq.in., an elongation of 200 per cent, and a bending moment of 0.75 in.lb. at −70°F. . . . To be more specific concerning the Parker Appliance item that appeared on page 79 of the June issue of the AERONAUTICAL ENGINEERING REVIEW, the line of valves acquired by Republic Manufacturing Company includes only Parker's "old General Purpose Valves—namely, Globe, Needle, Plug, and Ball Check Valves." Parker still continues to manufacture Specialized Aircraft Fuel-System Valves, including Selectors, Shut-off Valves, Swing Check Valves, Level Control Valves, etc. Accordingly, Parker has disposed of the General Purpose Valves only and is still making Aircraft Valves.

• **Phillips Petroleum Company**. . . The firm reports several important discoveries during the first quarter of 1952, the most important of which is said to be a new deep well in the Chocolate Bayou, Brazoria County, Texas Gulf Coast. There, Phillips holds approximately 14,500 acres favorably located for gas-distillate production from this deep sand zone.

• **Piasecki Helicopter Corporation**. . . Gareth W. Speer, Treasurer of the corporation, was elected Financial Vice-President. He will continue to serve as Treasurer and will also be responsible for financial policies and programs.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation**. . . Beginning July 1 and extending over a 3-year period, apprentice training to qualify as jet-engine metalsmiths is being given to young men between the ages of 18 and 21 who have a high school or technical trade school diploma or an equivalent education. This training will include 6,000 hours of classroom study and practical technical experience building Turbo-Wasp jet engines.

FLIGHT TEST PROGRAM

An extensive test program is now under way on Piasecki Helicopter Corporation's YH-21 Work-Horse, which made its first flight on April 11 from Philadelphia International Airport. Powered by a Wright Cyclone 9 (R1820-103) engine, the tandem twin-rotored helicopter can operate with an overload gross weight of more than 14,000 lbs., can fly at 125 m.p.h., and can operate at altitudes above 16,000 ft. The fuselage, of all-metal stressed-skin monocoque construction, is 52½ ft. long and 16 ft. high. The YH-21 is capable of transporting 14 troops or 12 litters plus a medical attendant in addition to its pilot and copilot. Piasecki is planning to build both rescue (YH-21 and H-21A) and transport (H-21B and H-21C) versions of the machine.

• **Republic Aviation Corporation**. . . A contract has been signed by Republic and Finmeccanica of Italy permitting the latter corporation to manufacture components and parts for the Republic F-84 Thunderjets being supplied to European nations under the Mutual Defense Assistance Pact. This move is part of a program intended to expedite the overseas maintenance of the North Atlantic Treaty Organization's fighter-bomber fleet. . . An F-84 Thunderjet placed on the deck of an aircraft carrier in late April marked the three-millionth ton of military equipment for delivery under the Mutual Defense Assistance Program. . . A turboprop version of the Thunderjet, designated the F-84H, is reportedly being developed. The ship will apparently be powered by an Allison T-40 engine.

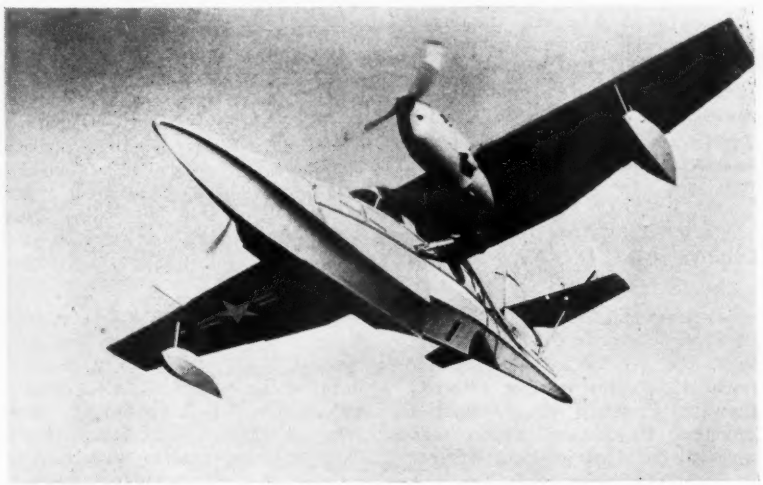
• **Rohr Aircraft Corporation**. . . A new $2,000,000 plant at Riverside, Calif., scheduled for completion by November 30, will be used for the production of power packages for Boeing KC-97's and other assemblies. An expansion of the Rohr facility at Chula Vista is also being planned.

• **Solar Aircraft Company**. . . A new booklet that outlines "cost-cutting solutions to common problems in metallic arc, inert arc, and other fusion welding of alloy steel" and which also describes the available types of Solar Flux can now be obtained from Solar's Flux Department in San Diego. . . Leon T. Noel, Comptroller, and Herbert Kunzel, Secretary and Director, were elected Vice-Presidents of the company.

• **Summers Gyroscope Company**. . . Edward C. Light, M.I.A.S., formerly Chief Engineer, was elected to the position of Vice-President in charge of Engineering.

• **Tinnerman Products, Inc.**. . . George J. Schad, Treasurer, and Robert C. Overstreet, Secretary, have been elected Vice-Presidents of Tinnerman. Both men were also re-elected to their previous offices.

• **Westinghouse Electric Corporation**. . . A new educational program, the Westinghouse-Johns Hopkins Awards in Electrical Engineering for 1952, has been established to help deserving young people pursue



A "NEW LOOK" IN WIDGEONS

A hull, the sixth experimental one to be built by Edo Corporation to U.S.N. specifications, was bolted onto a Grumman Widgeon and successfully flown by Edo last April. This new hull configuration was designed jointly by the Navy's Bureau of Aeronautics and Consolidated Vultee Aircraft Corporation for use in new large-size flying boats contemplated in the future. The hull features a length-to-beam ratio of 12.5 to 1, said to be the highest such ratio ever used. The rectangular window aft of the main step is for observation and filming of the water flow under the hull. This modified Widgeon has been turned over to the Naval Air Test Center, Patuxent, Md., for extensive flight tests and evaluation.

careers in the field of electrical engineering. The awards will enable 30 students each year to combine work experience at Westinghouse with technical studies, leading to a Certificate in Electrical Engineering to be granted by McCoy College of The Johns Hopkins University. Candidates are to be selected on the basis of tests, school records and recommendations, and interviews. The program is being administered by D. C. Lee, Manager of Industrial Relations, Westinghouse...Three Vice-Presidents were recently elected to head twelve of Westinghouse's 31 Divisions. They are: W. W. Sproul, L. B. McCully, and H. E. Seim.

Meet Your Section Chairman

C. F. Savage

Boston Section

Charles Francis Savage has been associated with General Electric Company since 1928, when he was graduated from Oregon State College with a B.S. degree in Electrical Engineering. During the first 3 years with G-E, he was assigned to Radio, Appliance, and Merchandise Engineering. In 1931, he was transferred to G-E's Meter and Instrument Department, where he has remained to the present.

From 1931 to 1939, Mr. Savage served as Technical Engineer, first, in Meter Engineering and, later, in the Works Laboratory. He was promoted to Section Head of Time Switch Engineering in 1939, and, within a year, he felt the urge "to apply creative effort in measurements to satisfy the needs of aircraft." In August of 1940, the opportunity to gratify this desire was given to him when he was appointed Section Head of Aircraft Instrument Engineering. Six years later, he became Designing Engineer and Assistant to the Works Manager, and in the following year, 1947, he took over his present duties as Assistant to the Manager of Engineering. As such, Mr. Savage is directly responsible for the design of various forms of aircraft devices, such as tachometer and other engine instruments, gyros for navigation and control, flight instruments, etc. Some of his current duties involve administrative work—directing a large number of Measurement Engineers at G-E's Measurement Laboratory.

Mr. Savage, who holds Patent No.2,415,707, Gyro Altitude Indicator, is a member of the Thomson Club, Sparkplugs Association, Tau Beta Pi, Eta Kappa Nu, Sigma Phi Epsilon, American Institute of Electrical Engineers, and National Society of Professional Engineers. His favorite hobbies are amateur radio and audio engineering.

Mr. Savage and his wife, the former Ruth Frances Stewart whom he married in July, 1930, are the parents of Ruth Janet, aged 17, and Edward Stewart, aged 11.

I.A.S. Sections

Chicago Section

Alfred F. Stott, *Secretary*

On April 15, the Chicago sections of A.S.M.E. and I.A.S. held a joint meeting at the Western Society of Engineers. Approximately 125 attended the program, which opened with a social hour sponsored by the Benjamin Electric Company of Des Plaines, Ill. At 6:15, dinner was served in the main dining room.

At the conclusion of the meal, Chairman D. J. Bergman, of A.S.M.E., welcomed those present and introduced E. C. Bailey who will be next year's chairman. All left the dining room for larger quarters in the main auditorium where Mr. Bergman introduced S. J. Tozer, the evening's chairman, who presented the dinner speaker, Elmer C. Maywald, President of Maywald & Company. He delivered a most interesting talk on "Applying Engineering to the Sport of Fishing—The Ten Millionth Glass Rod." His fine presentation made listeners feel they were with Mr. Maywald on his many fishing and sporting adventures.

At 8:15, the group divided and attended one of two sessions that ran simultaneously. The aircraft session was arranged by Rodney J. Schaid, Aviation Chairman of A.S.M.E., and Dr. H. L. Hull, Vice-Chairman of I.A.S. The speaker was Kimball C. Cummings, Assistant Chief, Aeronautical Research, Minneapolis-Honeywell Regulator Company. Mr. Cummings gave a very fine talk illustrated with slides on "Automatic Control in Flight." The wide military and electrical experience of the speaker provided the background for a very interesting discussion of the problems and experiences encountered and of what might be expected in the future with reference to automatic controls.

While the aircraft portion of the program was in progress, a Junior Member Prize Paper Contest was held for A.S.M.E. members who participated for cash awards. There were four contestants, the winner being James Marrissey, of the Zenith Corporation, who spoke on "Separation of Interrelated Variables." The audience also judged the papers, and the one whose judging grade was closest to that of the official judges received a slide rule.

An excellent question and answer session was held in both meetings. The program ended at 10:30.

Cleveland-Akron Section

Harrison C. Chandler, Jr., *Secretary*

"The Promise and Problems of Atomic Power" was the title of the paper presented by Gale Young at the April 22 meeting. Mr. Young is the Technical Director of Nuclear Development Associates, Inc., located at White Plains, N.Y.

The meeting, sponsored by Goodyear Tire & Rubber Company, was held in Goodyear Hall in Akron. About 300 members and guests attended. The program for the evening included conducted tours through the Goodyear Rubber Exhibit and dinner, which was provided free of charge by the Goodyear Company. E. W. (Pop) Cleveland, Section Chairman, presided. Mr. Young was introduced to the audience by Dr. Karl Arnstein, Vice-President of Engineering, Goodyear Aircraft Corporation.

Mr. Young's paper was a comprehensive survey on the subject of atomic energy. Topics discussed in the paper included the rapidly increasing magnitude of the A.E.C. operations, recent events of significance for atomic power, and the major problems that must be attacked in the future development of atomic power.

Concerning the magnitude of A.E.C. operations, Mr. Young stated that the total expenditure of funds thus far has been about $6,000,000,000, of which half has been used up, and the remainder is represented by existing plants and equipment. This investment in plant facilities places the A.E.C. in the same

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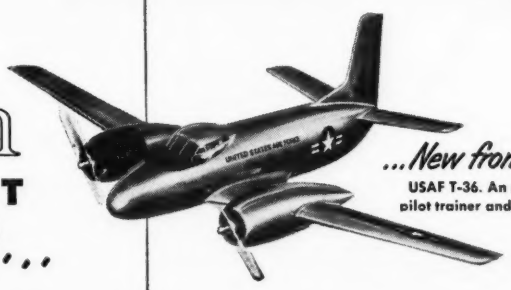

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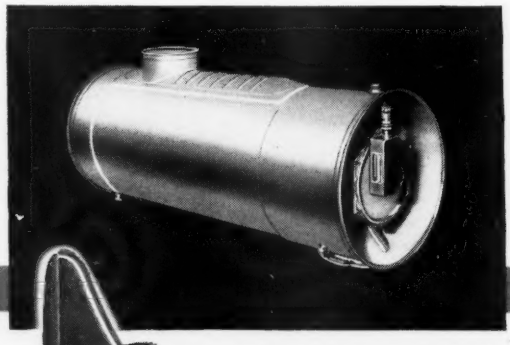

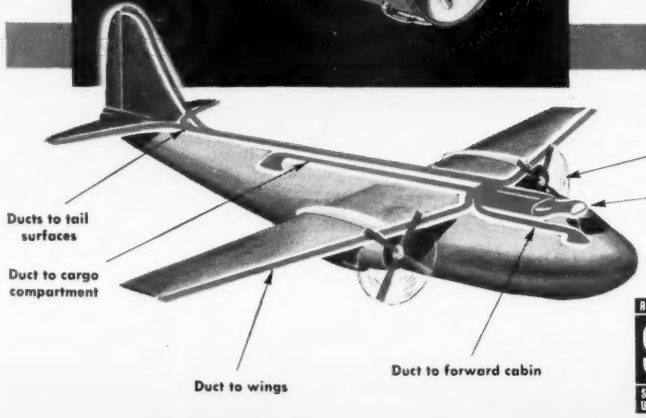
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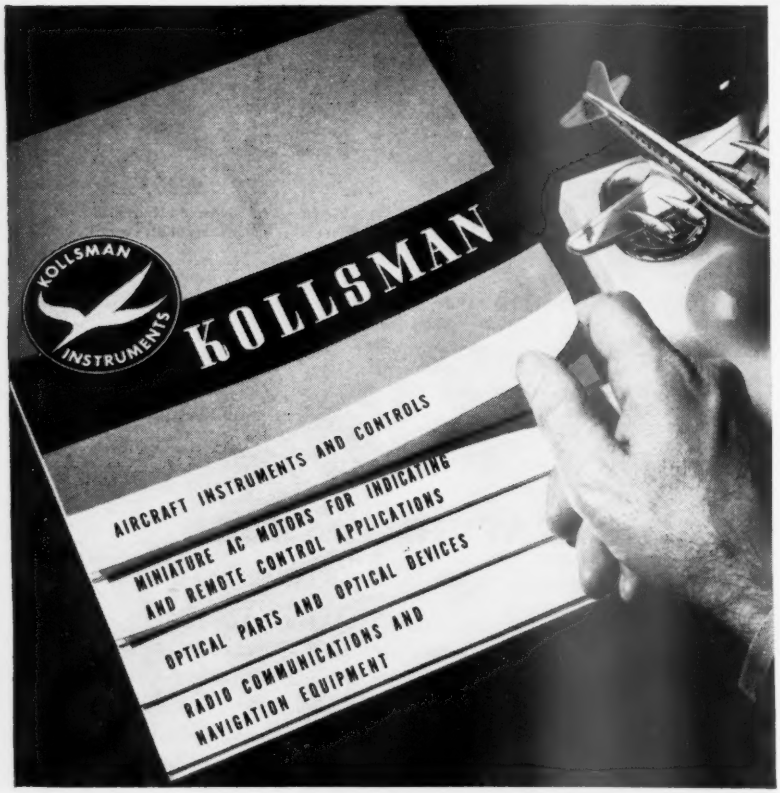

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class as U.S. Steel and A. T. & T. Current rate of expenditure is $1,800,000,000 per year. The two largest A.E.C. installations are the isotope separation plant at Paducah, Ky., and the plant at Savannah River, S.C., for making atomic-bomb and hydrogen-bomb materials. All present indications are that the atomic energy program will be expanded as rapidly as funds can be absorbed for this purpose.

With regard to the subject of mobile reactors, Mr. Young indicated that considerable progress has been made by the Argonne National Laboratory and the Westinghouse Electric Corporation in the development of a reactor for propulsion of a submarine. The Navy has already christened the submarine as the U.S.S. Nautilus. The General Electric Company is engaged in another project to develop a submarine nuclear reactor.

Mr. Young also discussed briefly the General Electric and Pratt & Whitney Projects to develop nuclear aircraft power plants and the corresponding projects of Consolidated Vultee and Boeing to build air frames for these atomic-powered engines. He gave the impression that the atomic-powered submarines are much further along than the atomic-powered airplanes.

On the question of atomic energy to furnish industrial power, Mr. Young said that four teams of two industrial companies each have organized, under arrangement with the A.E.C. this past year, to begin at their own expense studies and surveys on this subject. Electric power companies are represented on each of the four teams.

The development of a breeder-type reactor by the A.E.C. was considered by Mr. Young as especially important. In this process, each fission replaces not only the consumed neutron, as in the case of an ordinary fission chain reaction, but also the consumed atom of fissionable material. The required fertile materials (uranium 238 and thorium 232) exist in nature in much greater abundance than the naturally fissionable material (uranium 235) now being exploited. Thus, the breeder reactor development could ultimately enable us to expand the atomic program a hundredfold and, at the same time, to be free from depending on foreign ore supplies.

The major problem areas in atomic power were listed by Mr. Young as raw materials, breeder reactors, aircraft nuclear propulsion, and the harnessing of atomic energy for industrial power.

Mr. Young's paper will be published in its entirety in a forthcoming issue of the AERONAUTICAL ENGINEERING REVIEW.

Earlier in the meeting, Dr. R. P. Dinsmore, Vice-President for Research and Development, Goodyear Tire & Rubber Company, described the various materials and products that his com-

pany has produced for aircraft use over a period covering about the past 40 years. Prominent in this activity was the development of the dirigible and its great upswing between 1922 and 1933, during which years Goodyear built the Akron and the Macon. The company is continuing its work on blimps for the U.S.N. Current aircraft manufacturing and development activities of Goodyear are centered at the Goodyear Aircraft Corporation.

Hampton Roads Section

Albert L. Braslow, *Secretary*

The January 9 meeting with 65 members and guests present was addressed by W. I. Stieglitz, Design Safety Engineer, Republic Aviation Corporation. Mr. Stieglitz, who has a broad background in the field of airplane design and who recently served in the capacity of Accident Consultant for the Air Force, gave a most informative and interesting talk, amply illustrated with slides, on the importance of careful detail design. He pointed out that poor aerodynamic or structural characteristics of airplanes cause only a small percentage of accidents and that the main causes are oversights in the detail design and personnel error. He illustrated how personnel error, itself, can in many instances be the result of faulty detail design in that the design may not only permit, but actually induce, errors by personnel operating and maintaining aircraft.

According to Mr. Stieglitz, in the evaluation of instruments, structural parts, and cockpit controls, it is most important that careful consideration be given to (1) the possible effects, if the part malfunctions, (2) the effects, if an error is made in its installation, (3) the ease of inspection, and (4) the human reactions of pilots in time of emergency. He described how oversights in each of the foregoing respects had caused actual accidents and showed how only slight changes in the detail design could prevent repeats of a similar nature. In order to reduce the number of accidents caused by the so-called "pilot error," Mr. Stieglitz mentioned that it is necessary to accelerate research in the field of human engineering—i.e., the study of human habit patterns—so that the cockpit can be tailored to conform with the pilot's capabilities and normal reactions.

Ottawa Aeronautical Society

T. E. Stephenson, *Secretary*

The new executive for the forthcoming year is: Chairman, Group Captain C. W. Crossland, A.M.T.S., R.C.A.F.; Secretary, H. Oatway, Aeronautics Division, Defense Research Board, Ottawa; and Executive Committee,

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Philadelphia Section

Emily Rogers, *Secretary*

The regular monthly meeting was held on April 2 at the Engineers Club of Philadelphia. Chairman Harris Campbell presided with 160 members present.

The speaker for the evening was Dr. J. J. Coop, Head of the Sonar Branch, Anti-Submarine Warfare Division, Aeronautical Electronic and Electrical Laboratory, Naval Air Development Center, Johnsville, Pa. A brief résumé of his paper, "Sonar and ASW Aircraft Problems," follows:

"A majority of the 996 enemy submarines sunk during World War II was detected and located by sonar. Surface ship sonar was employed extensively and proved to be effective against slow-speed submarines. While radar cannot detect underwater objects, aircraft equipped with radar forced the submarine to remain submerged for long periods of time, thereby reducing its mobility and consequently its effectiveness. Ironically, this reduction in the mobility of the submarine led the Germans, first, to the invention of the snorkel, a breathing tube that permits the submarine to operate on diesel engines while submerged and, second, to the invention of the streamlined high-speed submarine, which makes much less noise than the slow submarine.

"Sonar systems may be used to detect submarines either by listening to the sounds they produce or by observing the echoes reflected from them. Moving ships and submarines produce sounds that vary with the type, size, speed, propulsion systems, and auxiliaries. By means of a directional hydrophone, a sonar operator is able to locate the bearing of targets detected by listening. Directional echo-ranging systems determine both the bearing and the range of the target.

"While visual means for displaying the sonar information are used, no adequate substitute for the human ear has been discovered. Since the high noise levels in aircraft tend to mask the sonar signals, some form of soundproofing is desirable.

"Since all moving ships produce noise, it is obvious that the self noise of a listening ship tends to mask the sound of distant ships or submarines; hence, the detection range of a moving ship decreases as it goes faster.

"The recently developed helicopter appears to fulfill the requirements for a sonar platform needed in combating the

high-speed submarine. It combines in one vehicle the high mobility required to overtake a fast submarine and the zero speed, hovering, which permits a sonar search without the disturbing self noise associated with a moving ship."

San Diego Section

H. L. Braasch, *Secretary*

The April 3 meeting of the San Diego Section was held in the Marine Room of the Hotel San Diego. The dinner was preceded by a short social hour in the lounge.

W. C. Heath, Chairman, introduced Ernie Stout, of Consolidated Vultee Aircraft Corporation, who in turn introduced the speaker of the evening, William B. (Bill) Stout.

Bill Stout is well known for his numerous significant contributions to the field of aviation during the past 35 years. Among his achievements are the first cantilever wing monoplane and the first all-metal airplane built in America. He was Chief Designer of the famous Ford Trimotor, many of which are still flying. In 1926, Mr. Stout formed one of the first passenger air-transport services in the United States. He has also made significant contributions in the fields of automotive and railroad development.

Mr. Stout's talk on "This New World We're In" linked many of his interesting experiences in early aircraft, automotive, and railroad development in this country to the present and future responsibilities of the technical personnel of American industry. Mr. Stout pointed out that in the future, as it has been in the past, the changes that affect the society of man will come through the ability of the technical worker to meet more and more complicated problems that arise.

Following the talk, the meeting attended by approximately 140 members and guests, was adjourned by Chairman Heath.

Texas Section

Charles L. Seacord, Jr., *Secretary*

A dinner meeting was held on February 28 at the Midway Inn, Arlington, Tex. Following the meal, John J. Hospers, Assistant to the General Manager, Chance Vought Aircraft Division of United Aircraft Corporation, described his recent trip to the Korean front. Mr. Hospers' trip, made under Navy auspices, was for the purpose of observing aircraft operations under combat conditions. The itinerary included two aircraft carriers and several Marine ground squadrons. Mr. Hospers' verbal description was supplemented by slides and films. Of particular interest were movies of helicopter

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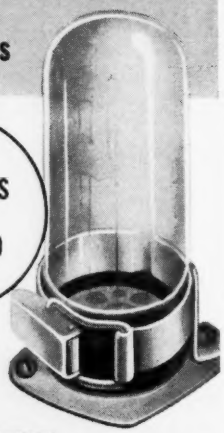

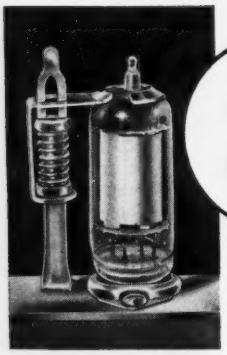

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operations taken from a helicopter while flying over the front lines in Northern Korea.

▶ The April 3 meeting featured an after-dinner address by Dr. Heinz Haber, Department of Space Medicine, U.S.A.F. School of Aviation Medicine. The lecture, which was opened to the public, was attended by about 300 persons.

Dr. Haber told of the inception of the Department of Space Medicine and gave a general outline of its work. He then described and illustrated with slides the several criteria by which the end of the atmosphere and the beginning of space can be set. These criteria are: the respiration limit, the height at which drag becomes negligible, the height at which cosmic radiation becomes constant, and the height at which small meteors become dangerous.

In connection with the recent article in Collier's magazine, Dr. Haber stated that, while a man-made satellite appears to be feasible, he holds no hope of frequent interplanetary travel becoming either an economic or a technical possibility. The widespread realization of this fact, Dr. Haber believes, will be of great benefit in convincing all the peoples of the earth that a policy of conservation of mineral resources is a necessity for continued social and technical development.

Washington Section

J. H. Sidebottom, *Secretary*

The April 1 meeting was opened by Dr. Hugh L. Dryden, N.A.C.A. Director, who introduced Don Auld, Chairman of the student contest program. Mr. Auld described the establishment of a student contest program in the Washington Section this year and said that the papers of the two student finalists would be judged by Ivan Driggs, of the Navy's BuAer; Dr. Frank Wattendorf, U.S.A.F.; and Dr. Dryden.

William S. Bissell, a senior student at the University of Maryland, presented a brief outline of his paper entitled "Use of Ballistics Range To Obtain Drag and Air Flow Properties at Supersonic Speeds." This paper outlined the extent of experiments, conducted at the University of Maryland, relating to the use of ballistics testing equipment to compare various profile shapes of aerodynamic bodies and to obtain drag and airflow properties at supersonic speeds. Mr. Bissell had concluded that this equipment provided a desirable tool for basic research and for instruction in aerodynamics for the university student. Joseph F. Chamberlain, a junior student at Catholic University, presented a brief outline of his paper entitled "Aerodynamic Characteristics of a Channel Wing" which outlined the research and

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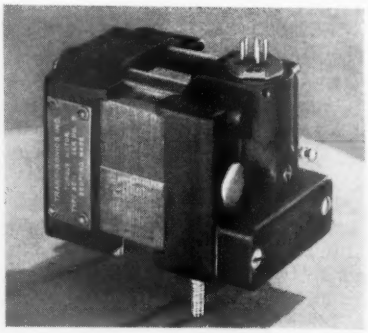

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experiments that he had conducted to determine the relative advantages and disadvantages of channel-wing construction for certain types of aircraft. Mr. Chamberlain concluded that under certain limiting operating conditions and with certain aircraft power plant configurations, the channel wing offered surprisingly good lift-drag characterstics and, for certain specialized types of vehicles, might prove superior to conventional wing construction.

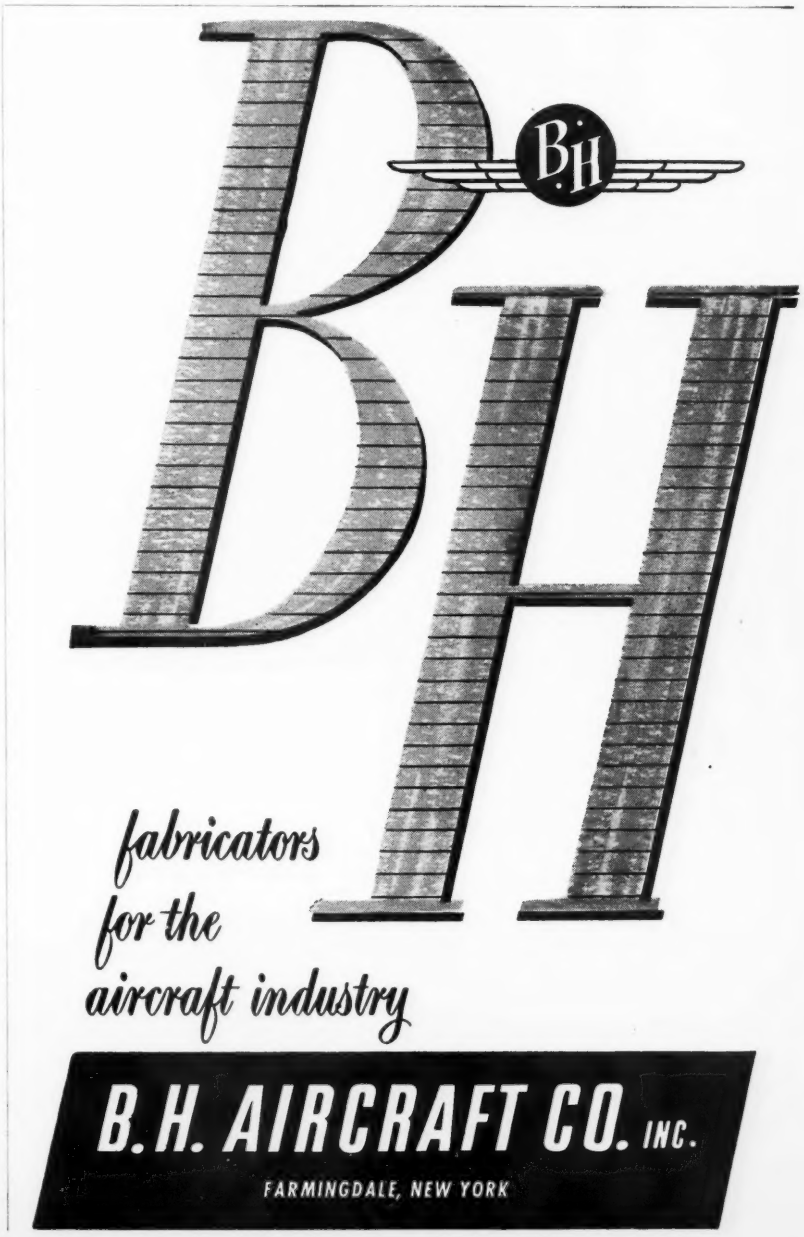
At the conclusion of the presentations by the student contest finalists, the judges announced Mr. Bissell's paper as the winning paper. Chairman Dryden presented the prizes and commented upon the excellence of both presentations.

Captain Charles F. Blair, of Pan American World Airways, presented the feature speech of the evening on "Trans-Polar Flight." Captain Blair described how his hobbies and odd conglomeration of aeronautical activities, including test and military flying, ownership of a small nonscheduled air line, and 19 years of flying with scheduled air lines, had led him to the decision to attempt a solo flight across the North Pole from Norway to Alaska last year. He described the F-51 Mustang airplane, which he purchased from Paul Mantz who had used the ship to win two Bendix Trophy Races. It was modified extensively through the addition of navigational equipment and tankage to permit long-range flying. After 50 hours of shake-down flying, including a nonstop trip between Fairbanks and Los Angeles, Captain Blair brought the plane to New York and thence nonstop to London in record time.

Captain Blair then described, in detail, the preparations that were made for his flight from Norway and the details that went into the specific flight plans for two separate days in the event of any mechanical delay. It happened that he used the first flight plan, which provided for navigational checks on the sun every 10 min. supplemented by other celestial checks on an hourly basis. By the time he had reached his first radio check, Point Barrow, he was less than 1 min. off the scheduled flight plan. In this discussion, Captain Blair related his experience to the future picture for air transport traffic over the North Polar regions. By glancing at the map, he pointed out that the distance from Northern Europe—including Great Britain, Scandinavia, northern Germany, and northern France—to the Japanese Islands is notably less via the Polar route to Alaska than it is via the only other available route through southeast Asia. From an operational standpoint, he stated that it would not take much in the way of additional facilities to allow present transports to fly with equal regularity and equal pay loads over the Polar icecap.

The number one requirement is an airport on Spitzbergen where the terrain and weather are satisfactory. Secondly, there is a need for longer runways at some airports in Sweden and Norway and at Point Barrow, Alaska. For the twilight part of the year, a strong homing range on Spitzbergen would be desirable; Point Barrow already has such a range. Mid-air refueling might be an alternative for the foregoing requirements. He pointed out that the controlling leg is that from Spitzbergen to Point Barrow, something less than 2,300 statute miles, comparable to the controlling leg of the transatlantic operations, Bande to Shannon, 2,000 miles. The Arctic weather presents no problem to high-altitude long-range aircraft. Cloud tops are lower, winds aloft are normally lighter than at the mid-latitudes, and terminal weather is not critical. Alaska has unlimited alternate facilities. Navigation in summer and winter would require a combination of celestial and radio checks. In the twilight season, it would be primarily radio navigation with limited celestial navigation. He concluded by stating that aircraft performance would be superior in the lower temperatures of the Arctic with particular reference to take-off performance and pay load.

At the conclusion of the meeting, Dr. Dryden presented certificates of appreciation to the outgoing officers of the



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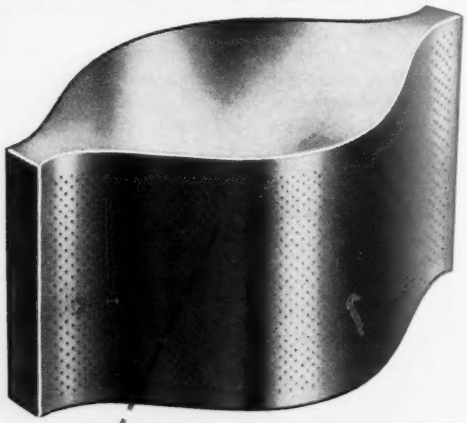

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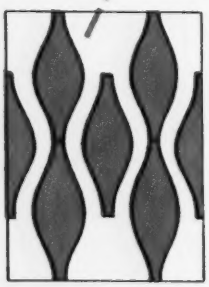

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Washington Section. James Dougherty, outgoing Treasurer, announced the results of the recent election for the 1952–1953 officers: Chairman, J. H. Sidebottom; Vice-Chairman, Col. John H. Carter; Secretary, Capt. Paul J. Burr; and Treasurer, R. J. McCrea.

Student Branches

The Catholic University of America

Chairman Earl Erickson presided at the March 27 meeting, which was attended by 25 students. Student Member Joseph Chamberlain delivered a paper on the "Characteristics of the Channel Wing." This same paper was presented at the April 3 meeting of the I.A.S. Washington Section in a student paper competition and was awarded second prize.

▶ On April 13, an election of officers for the 1952–1953 academic year was held with the following results: Chairman, Earl Erickson; Co-Secretaries, Warren Eilertson and William Elsen; and Treasurer, Francis Augustine. Student Member James D. Trent spoke on the "Effect of Open Circular Holes on the Fatigue Strength of Sheet Specimens of Aluminum Alloy." The meeting was concluded with the showing of two films, *The Story of the Ram Jet* and *Aircraft Oddities*. Chairman Erickson presided; 20 persons were present.

University of Colorado

The April 24 meeting was called to order by Chairman Burt R. Benson, who introduced the speaker, Clayton C. LaVene, Engineering Division Employment Manager, Douglas Aircraft Company, Inc. Mr. LaVene first showed a film entitled *Operation Airborne*, which depicted the duties and capacity of the U.S.A.F.'s C-124 Globemaster. Mr. LaVene then discussed planes that have been produced at Douglas and described the various divisions of the company in which employment is available. The speaker answered all questions by the group concerning future employment. Eighteen students were present.

University of Detroit

As a result of an election of officers at the March 31 meeting, the following students become the executive: Chairman, Jack Shea; Vice-Chairman, James Meyers; Secretary, Ray Piziali; and Treasurer, Hubert Harold. Following the elections, four films were shown—*Gyroscope, Air Force Voodoo, Air Force Goblin*, and *C-124 Globemaster*. Chairman George Paul Himes presided; 18 students were present.

University of Florida

Professor Robert Thompson, Head, Department of Aeronautical Engineering, University of Florida, addressed the March 25 meeting on the subject of "The Aeronautical Engineer." The meeting was attended by 25 students and led by Chairman Roy F. Dutton.

University of Illinois

The April 2 meeting was opened by Chairman Frank Vileta with 19 students present. The speaker was Prof. H. Stillwell, Head, Aeronautical Engineering Department, University of Illinois, who spoke on "Jobs and Opportunities." Professor Stillwell presented an encouraging picture for both those persons now graduating and those who will be graduated in the next 4 years.

Iowa State College

A film on *Air Progress* was shown at the April 16 meeting.

Massachusetts Institute of Technology

Chairman James Flanders presided at the April 3 meeting at which Horton Guyford Stever, Associate Professor of Aeronautical Engineering, M.I.T., delivered a lecture on "Guided Missiles." Professor Stever included his personal experiences during the development of the guided missile and explained the role of the new college graduate in the field. The meeting was attended by 17 students.

On April 17, 23 students were present to see the presentation of a British film entitled "*University of Flying.*" Chairman Flanders presided.

New York University

On April 9, 25 members from New York University toured the United States Navy Special Devices Center at Port Washington, N.Y. The group was shown, among other things, a recently developed wide-angle lens for motion picture projectors, a flight engineer's training panel, and a celestial navigation trainer.

Elections for the coming year were held at the meeting of May 1. The following men were elected to office: Chairman, William Zeltner; Vice-Chairman, Samuel Sugarman; Secretary, John Schmitt; and Treasurer, Nicholas Vretakis.

A film *Little Henry* was shown at the meeting of May 8. Chairman William Zeltner presided. About 25 students were present.

North Carolina State College

An election of officers was held at the April 8 meeting with the following re-

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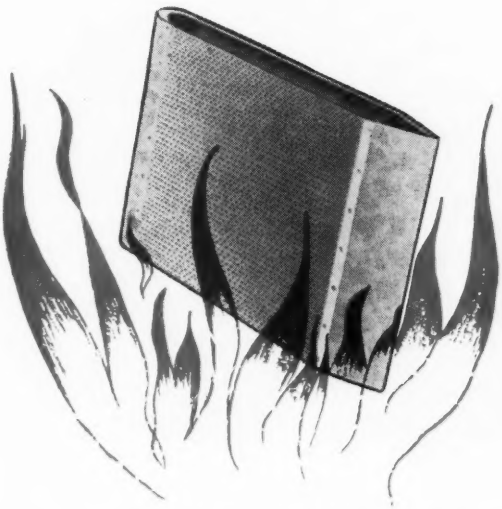

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sults: Chairman, Alfred Lamar Bell; Vice-Chairman, Howard D. Green; Secretary, Mary Ellen Short; Corresponding Secretary, Ralph E. Deitrick; and Treasurer, Ralph J. Blalock. Chairman Arthur A. Crews presided; nine persons were present.

The Ohio State University

On April 2, Barkley Walker, Supervisor of Engineering Training, North American Aviation, Inc., spoke to the 25 attending students on the "Apprenticeship of the Engineer." Chairman Richard G. Docken presided.

▶ On April 23, an election of officers for 1952–1953 was held with the following results: Chairman, Paul Schumacher; Vice-Chairman, Douglas Drake; Secretary, Richard Edwards; and Treasurer, John Richardson. A talk on "Aerodynamic Parameters" was given by Morgan Blair of North American Aviation, Inc. Chairman Richard G. Docken presided; 13 students were present.

The University of Oklahoma

Chairman Melvin E. Dell called the meeting of April 2 to order and introduced the speaker, Glenn C. Grimes, an I.A.S. student member at Oklahoma. Mr. Grimes delivered a lecture on "The Effect of Wing Bending Deflection on the Rolling Moment Due to Sideslip." The talk was followed by the showing of colored film slides of various parts of the country by Prof. L. A. Comp.

The Pennsylvania State College

An election of officers was held at the April 23 meeting, which was attended by 54 persons. The election results were: Chairman, Max Schuster; Vice-Chairman, John Gaul; and Secretary-Treasurer, Frank Lederer. A talk on "Safety Considerations in the Design and Operation of Transport Aircraft" was given by student member Hugh Garber. Chairman George Page led the meeting.

University of Washington

On February 11, Commander Davies, U.S.N., Sand Point Naval Air Station, Seattle, Wash., spoke on "Design Problems." Chairman Byrne C. Mackey presided.

West Virginia University

The officers for 1952, elected at the February 7 meeting, are: Chairman, E. J. Fourney, Jr.; Vice-Chairman, S. C. Hill; Recording Secretary-Treasurer, M. H. W. Ullock; and Corresponding Secretary, W. R. Barton.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Cleveland, E. W., Vice-President & Dir., Cleveland Pneumatic Tool Co.; Founder & President, Aero Engineering, Inc.; Vice-President, Airframe Supply Co.

Forsten, Irving, M.M.E., Head, Analysis Br., Naval Air Rocket Test Station (Lake Denmark).

Messinger, Bernard L., B.S. in M.E., Dept. Mgr. of Thermodynamics, Lockheed Aircraft Corp. (Burbank).

Samaras, Demetrios G., Sc.D., Chief of Propulsion Research, W.A.D.C., U.S.A.F., Wright-Patterson A.F.B.

Zabriskie, Jesse H., M.S. (Aero.), Chief Test Engr., Bell Aircraft Corp.

Elected to MEMBER Grade

Aronson, Moses, M. of Ae.E., Aero. Engr., Special Devices Center, U.S.N. (Port Washington).

Beal, Ralph R., Jr., A.B., Aerodynamicist, Douglas Aircraft Co., Inc. (Santa Monica).

Beckmann, Herbert K., Dipl. Engr., Aerodynamicist, Anderson, Greenwood & Co.

Bennet, William J., B.S.C.E., Engrg. Supvr., Design Sect., Marquardt Aircraft Co.

Bijlaard, P. P., C.E., Prof. of Struct. Engrg., Cornell Univ.

Ehricke, Krafft A., Chief, Gas Dynamics Sect., Guided Missiles Devel. Group, U.S. Army Ordnance (Redstone Arsenal).

Ikola, George H., B.S. in E.E., Chief of Struct., Douglas Aircraft Co., Inc. (Long Beach).

Kent, William D., President, Flight Engineers' International Association.

Kirk, Jacques A., Dipl. in M.E., Wind Tunnel Supt., Short Bros. & Harland Ltd. (Belfast).

Kramer, Louis T., B.S. in C.E., Engrg. Designer (Hydraulics & Landing Gear), Douglas Aircraft Co., Inc. (Long Beach).

Mohler, Paul O., B.S.B.A., Proj. Office Staff, Northrop Aircraft, Inc.

Oldaker, Merritt R., B.S., Aerodynamicist, Lockheed Aircraft Corp.

Palmer, William H., B. of Ae.E., Aero. Engr., Ramjet Sect., Marquardt Aircraft Co.

Resler, Edwin Louis, Jr., Ph.D. in Ae.E., Asst. Prof. in Aero. Engrg., Cornell Univ.

Ritchey, Wallace M., Jr., B.S.M.E. (Aero.), Capt. & Proj. Engr., All Weather Sect., Flight Test Div., U.S.A.F., Wright-Patterson A.F.B.

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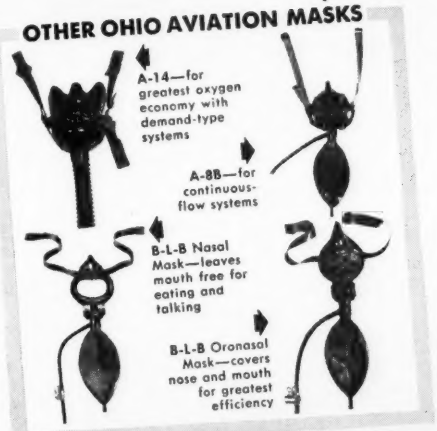
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Schmidt, Louis V., P.E. in Aero. Aerodynamicist "A," Boeing Airplane Co. (Seattle).

Schroeder, Leslie L., LL.B., Commissioner, Dept. of Aeronautics, State of Minnesota.

Sert, Louis R., B.S., Design & Devel. Officer, Aero. & Staff Engr., Chemical Corps Biological Labs., U.S.A.F. (Ft. Myer, Va.).

Stafford, Alfred B., Ph.D. (Social Science), Assoc. Prof., Dept. of Mech. Engrg., Univ. of Wyoming.

Svendsen, Norman F., M.S., Chief Designer, Marquardt Aircraft Co.

Teel, Lewis W., M.A., Proj. Engr., Douglas Aircraft Co., Inc. (Long Beach).

Trauger, Robert J., M.S. & A.E., Comdr., U.S.N.; Acting Dir., Office of Naval Research (Pasadena).

Vaughn, William R., B.S., Stress Analyst, Douglas Aircraft Co., Inc. (Long Beach).

Walther, Ernest P., Group Engr., Douglas Aircraft Co., Inc. (Long Beach).

Weber, E. Joseph, B.S. in C.E., Proj. Engr.—Struct., The Glenn L. Martin Co.

Wheeler, James W., B.S. in E.E., Dept. Head for Engine Instruments, Sperry Gyroscope Co. Div., The Sperry Corp.

Wildsmith, Brian C., A.M.I.E.T. (Aero.), Aero. Engr. "A," Hughes Aircraft Co.

Wilson, John R., B.S., President, Hanlon & Wilson Co.

Wise, James C., B.S., Chief, Mechanical Design Sect., Marquardt Aircraft Co.

Transferred to MEMBER Grade

Blakely, Carl F., B.S.M.E. (Aero.), Flight Analyst "A," Boeing Airplane Co. (Seattle).

Bowers, Robert W., B. of Ae.E., Aerodynamicist, Douglas Aircraft Co., Inc. (Long Beach).

Cotecchia, Ugo A., M.S.E., Research Assoc., Univ. of Michigan.

Felder, Harry, B. of Ae.E., Design Engr., Convair (San Diego).

Flora, Clarence C., B.Ae.E., Engrg. Designer "B," Boeing Airplane Co. (Seattle).

Goodmanson, Lloyd T., M.S., Chief Wind Tunnel Engr., Aerodynamics Unit, Boeing Airplane Co. (Seattle).

Graham, David, B.S. in Ae.E., Aero. Research Scientist, Ames Aero. Lab., N.A.C.A.

Hamilton, William T., M.S. in Ae.E., Sr. Group Engr., Boeing Airplane Co. (Seattle).

Howard, John R., M.S. in M.E., Proj. Engr.—Missile Evaluation, Army Ordnance Corps (Las Cruces).

Howell, Clarence S., Jr., A.E., Engrg. Designer "B," Aerodynamics Unit, Boeing Airplane Co. (Seattle).

Jones, Ira P., Jr., M.S. in A.E., Aero. Research Scientist—Aerodynamics II, N.A.C.A., Edwards A.F.B.

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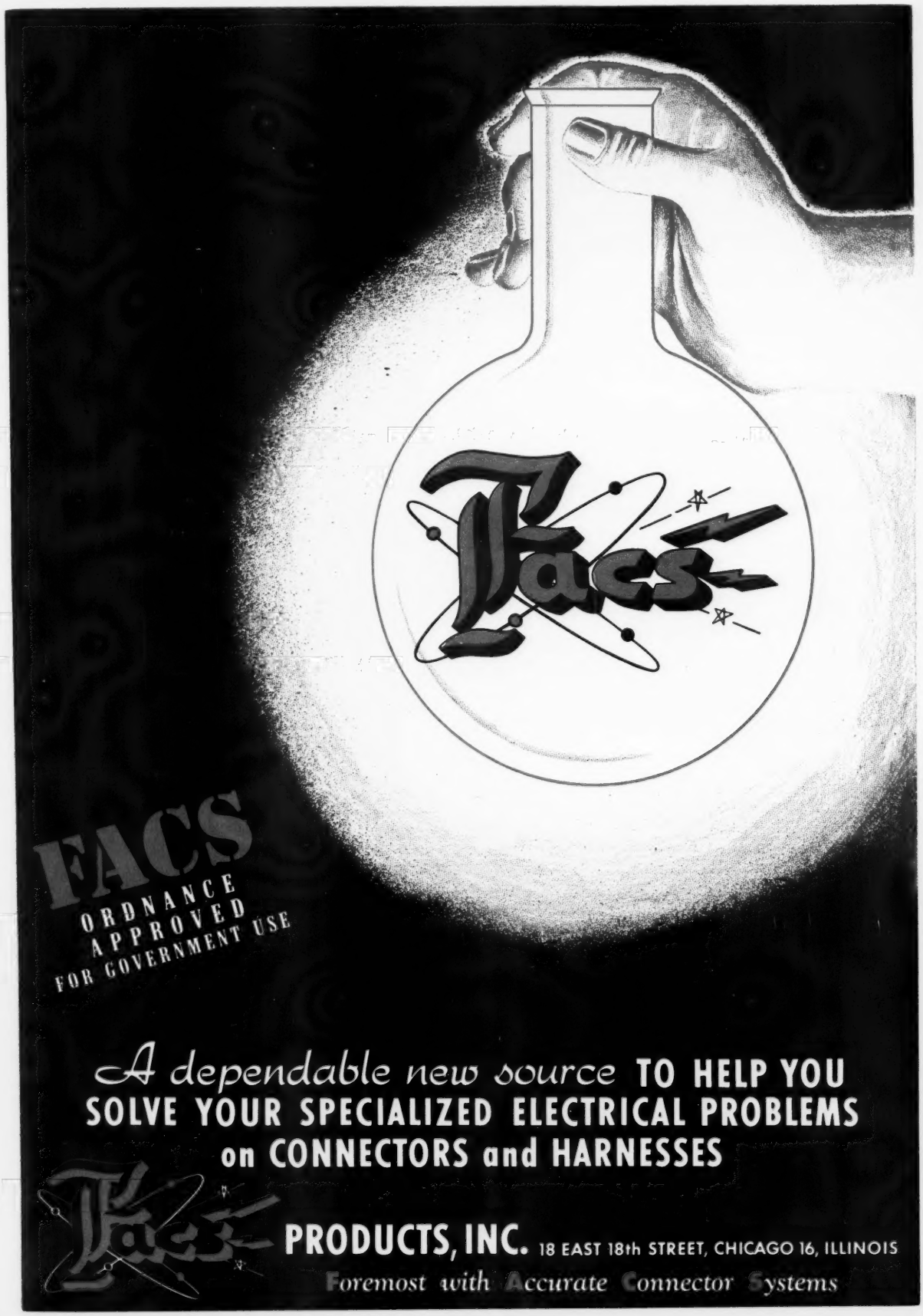
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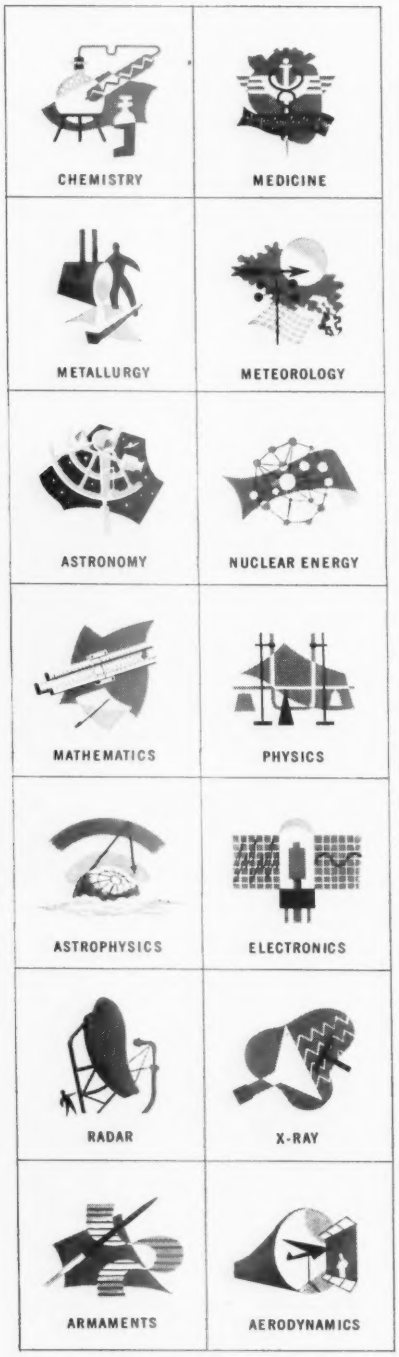

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Mayers, Jean, M. of Ae.E., Aero. Research Scientist, Struct. Theory, N.A.C.A., Langley A.F.B.

Mohrman, Robert F., B.Ae.E., Applied Loads Engr., Grumman Aircraft Engineering Corp.

Paiss, Hal, B.S. in M.E., Proj. Engr. & Deputy to Gen. Mgr., Inter Continental Airways, Inc.

Pannell, Robert L., B.S. in M.E., Proj. Engr., Pacific Div., Devel. Labs., Bendix Aviation Corp.

Snow, John E., B. of M.E., Capt., Asst. Officer in Charge, Production Facilities & Drafting, U.S.A.F.

Sunday, William W., B.S., Staff Exp. Pilot, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Woersching, Thomas B., LL.B., Chief Aerodynamicist, Goodyear Aircraft Corp.

Elected to Associate Member Grade

Lee, Earle V., Chief, Document Service Center, Armed Services Tech. Information Agency, U.S.A.F. (Dayton).

Tarbox, William H., Flight Engr., Trans World Airlines.

Elected to Technical Member Grade

Faison, M. Frances, B.S., Mathematician, N.A.C.A., Langley A.F.B.

Gay, Lionel O. H., Draftsman, Grade III, A. V. Roe Canada Ltd.

Lawrence, William L., B.S. in Ae.E., Field Engr., Dept. 1881, Sperry Gyroscope Co. Div., The Sperry Corp.

Oakley, Rodney H., B.Sc.E., Flight Test Engr., Canadair, Ltd.

Rodriguez, Alexander M., B.S., Aerodynamicist, Douglas Aircraft Co., Inc. (Santa Monica).

Schmit, Lucien A., M.S.—Structural Engineering, Engr., Grumman Aircraft Engineering Corp.

Sheehan, Raymond J., Jr., B.S. (Eng.), Application Engr., Aircraft Gas Turbine Dept., General Electric Co. (W. Lynn).

Story, Philip C., Sr., M. of Engrg., Proj. Engr., Remote Flight Controls Systems, Sperry Gyroscope Co. Div., The Sperry Corp.

Tanner, Walter I., B.S., Engrg. Designer "B," Douglas Aircraft Co., Inc. (Long Beach).

Wild, Rolf, B.Sc., Armament Liaison Engr., Oerlikon Machine Tool Works, Buehrle & Co. (Zurich); assigned to Washington, D.C.

Transferred to Technical Member Grade

Bearden, Bruce M., Jr. Design Engr., Arizona Div., Goodyear Aircraft Corp.

Beydler, Lee W. G., B.S.M.E., Research Engr., Northrop Aircraft, Inc.

Blackman, Martin S., B.E. in Ae.E., Research Analyst, North American Aviation, Inc. (Downey).

Buckey, Don L., B.S. in Ae.E., Engrg. Asst., Struct. Design Group, Aircraft Div., McDonnell Aircraft Corp.

Carlson, David W., B.S. in Ae.E., Flight Test Analyst, Power Plant Group, North American Aviation, Inc. (Los Angeles).

Carney, Charles J., B. of Ae.E., Engr., General Aircraft Design Sect., Goodyear Aircraft Corp.

Carroll, John W., Engrg. Draftsman "B," Republic Aviation Corp.

Carroll, Patrick C., B.S. in Ae.E., Aero. Engr.—Proj. Officer, W.A.D.C., Wright-Patterson A.F.B.

Culp, Merle H., B.S. in M.E. (Aero.), Major, U.S.A.F.; Chief, B-29–B-50 Proj., Weapon Systems Div., W.A.D.C., Wright-Patterson A.F.B.

Culpepper, Raymond L., B. of Ae.E., Engrg. Contact Man-Liaison, Atlanta Div., Lockheed Aircraft Corp.

DeCell, Roy W., Struct. Engr., Northrop Aircraft, Inc.

Degnan, William J., Jr., Electro-Mechanical Draftsman, Special Weapons Dept., Instrumentation Design Group, Northrop Aircraft, Inc.

Dewey, Gaylen L., B.S. in Ae.E., Jr. Engr.—Struct. Group, Convair (Ft. Worth).

Diemer, Ewald R., B.S. in Ae.E., Jr. Engr.—Flight Test Instrumentation, Chance Vought Aircraft Div., United Aircraft Corp.

Dobronski, Joseph F., Tech. Analyst—Flight Test, McDonnell Aircraft Corp.

Dolim, Henry P., Engrg. Draftsman "A," Northrop Aircraft, Inc.

Donahue, Mark T., Engrg. Design Draftsman, Lockheed Aircraft Corp.

Eaton, Harley E., Draftsman, Engr. I, Bell Aircraft Corp.

Garlasco, Felix M., Methods Engr.—Trainee, Republic Aviation Corp.

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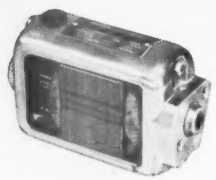

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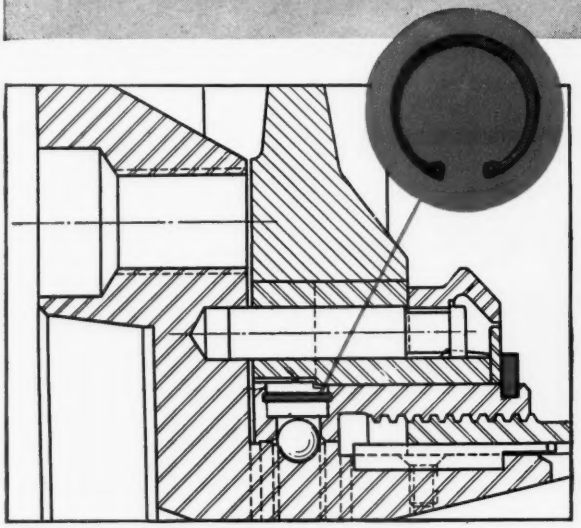

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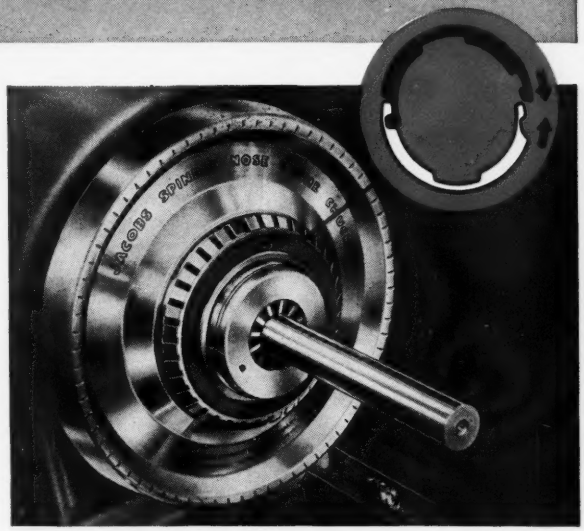

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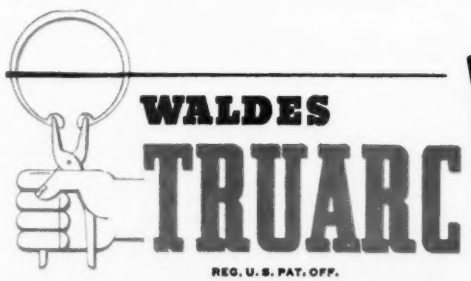

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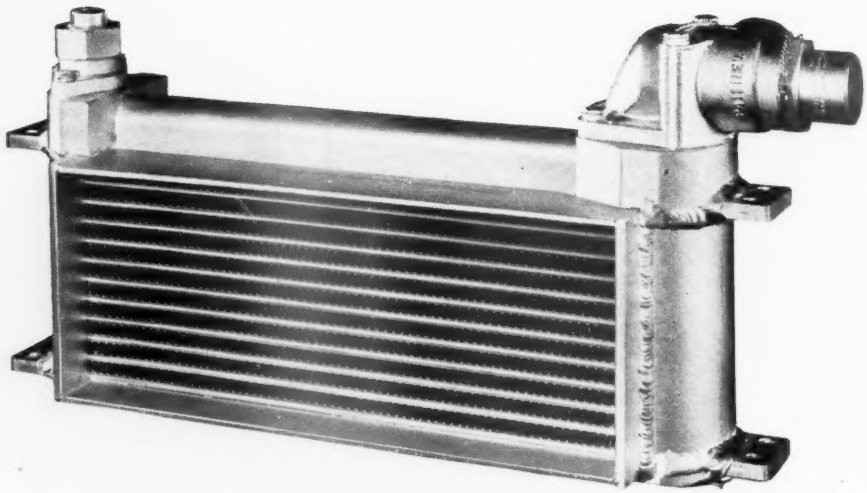

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Aerodynamics (2)

BOUNDARY LAYER & THERMOAERODYNAMICS

Boundary-Layer Studies on a Sailplane. August Raspet. *Aeronautical Engineering Review*, Vol. 11, No. 6, June, 1952, pp. 52–60, illus. 23 references. Supersedes Mississippi State College, Engineering Research Station, Research Report No. 1, December 31, 1951.

Heat-Transfer to Constant-Property Laminar Boundary-Layer Flow with Power-Function Free-Stream Velocity and Wall-Temperature Variation. Solomon Levy. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 341–348, illus. 11 references.

Numerical calculations that describe the combined effects of the free-stream velocity and wall-temperature variation and of variation in the Prandtl Number of the fluid on the heat transfer; comparison with the results obtained by Schuh and by Chapman and Rubesin. The calculations cover Prandtl Numbers ranging from 0.70 to 20.0 for wedge-flow values of $m = 4, 1, 0$, and -0.0904, and a range of wall-temperature function exponents from -2.5 to 4.0.

An Analysis of Laminar Free-Convection Flow and Heat Transfer About a Flat Plate Parallel to the Direction of the Generating Body Force. Simon Ostrach. *U.S., N.A.C.A., Technical Note No. 2635*, February, 1952. 47 pp., illus. 13 references.

Development of a general method of analysis for free-convection flow at high Grashof Numbers about a flat plate parallel to the direction of the body force. Velocity and temperature distributions are computed for Prandtl Numbers of 0.01, 0.072, 0.733, 1, 2, 10, 100, 1000, and for large Grashof Numbers.

Readers' Forum: Recovery Factors for the Laminar "Separation" and Stagnation Flows. S. Levy and R. A. Seban. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 355–357, illus. 5 references.

Theoretical results for the value of the recovery factor at a Prandtl Number of 0.7 for the velocity profile in the boundary layer which corresponds to conditions at separation of the boundary layer and for stagnation flow.

Heat Transfer in Isotropic Turbulence. Stanley Corrsin. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 113–118. 18 references.

Derivation of an expression for the turbulent heat-transfer coefficient which depends only on the velocity field, and of an approximate expression for the corresponding correlation coefficient which depends only on velocity field and fluid physical properties.

Unsteady Laminar Flow of Gas Near an Infinite Flat Plate. C. R. Illingworth. *Cambridge Philosophical Society, Proceedings* Vol. 46, Part 2, October, 1950, pp. 634–641, illus. 7 references.

Readers' Forum: Further Comments on "The Effect of Surface Cooling on Laminar Boundary-Layer Stability." Martin Bloom. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, p. 359. 6 references.

Readers' Forum: Comments on "Turbulent Boundary-Layer Characteristics at Supersonic Speeds—Theory and Experiment" by R. E. Wilson. Marvin L. Luther. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, p. 357.

FLUID MECHANICS & AERODYNAMIC THEORY

Induced Mass with Free Boundaries. Garrett Birkhoff. *Quarterly of Applied Mathematics*, Vol. 10, No. 1, April, 1952, pp. 81–86, illus. 7 references. Extension of the concept of induced mass, and some of its properties, to the case of an incompressible liquid having a free surface.

Note on the Motion of Liquid Near a Position of Separation. W. R. Dean. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 2, April, 1950, pp. 293–306. 3 references.

A Mixing Theory for the Interaction Between Dissipative Flows and Nearly-Isentropic Streams. Luigi Crocco and Lester Lees. *Princeton University, Aeronautical Engineering Laboratory, Report No. 187*, January 15, 1952. 98 pp., illus. 22 references.

A Water Analogue of the Isentropic Flow of Compressible Gases Which Have Arbitrary Ratios of Specific Heats. Ronald F. Probstein and George E. Hudson. *U.S., Office of Naval Research, Project Squid, Technical Report No. 15*, August, 1948. 24 pp., illus. 3 references.

Mathematical development of the theory of obtaining a water analog of the gas flow for which the γ (the ratio of specific heats) is other than 2.0, for obtaining sound-wave velocities; experimental verification of the theory.

The Compressible Flow Corresponding to a Line Doublet. J. W. Craggs. *Quarterly of Applied Mathematics*, Vol. 10, No. 1, April, 1952, pp. 88–93, illus. 2 references. Type of limit line and singularities that occur in the transformation from the hodograph plane to the physical plane for the compressible flow due to a line doublet.

Some Solutions of the Equations of Flow of a Viscous Compressible Fluid. C. R. Illingworth. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 3, July, 1950, pp. 469–478. 4 references.

The Unsteady, Subsonic Motion of a Sphere in a Compressible Inviscid Fluid. A. L. Longhorn. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 64–81, illus. 2 references.

Analytic investigation of the effect of compressibility on the work required to accelerate a rigid sphere, immersed in a fluid, from rest to a uniform velocity.

High-Speed Flow of a Gas Past an Approximately Elliptic Cylinder. H. C. Levey. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 3, July, 1950, pp. 479–490. 5 references.

Exact solutions for the problem of the two-dimensional flow of a compressible perfect fluid about an elliptic cylinder of arbitrary eccentricity and angle of attack, assuming zero circulation.

A Comparison of the Experimental Subsonic Pressure Distributions About Several Bodies of Revolution with Pressure Distributions Computed by Means of the Linearized Theory. Clarence W. Matthew. (*U.S., N.A.C.A., Research Memorandum No. L9F28*, 1949.) *U.S., N.A.C.A., Technical Note No. 2519*, February, 1952. 52 pp., illus. 10 references.

The Boundary Layer Nature of Shock Transition in a Real Fluid. G. S. S. Ludford. *Quarterly of Applied Mathematics*, Vol. 10, No. 1, April, 1952, pp. 1–16, illus. 6 references.

Analysis of the shock phenomenon in compressible fluids which is based solely on a system of partial differential equations (Navier-Stokes equations) that govern the motion of a viscous, heat-conducting compressible fluid; no additional assumptions are introduced. It is proved that the integrals of these equations include a class of solutions of the boundary-layer type. In the limit the values of the resulting variables, for a small viscosity coefficient, on the two sides of the transition are subject to equations identical to the Rankine-Hugoniot conditions. These conditions, obtained in this analysis without any hypotheses, are proved to be necessary and sufficient for the existence of shocks.

Aerodynamics of Blasts. L. Ting and H. F. Ludloff. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 317–328, illus. 8 references.

Readers' Forum: The Shock Strength in a Two-Dimensional Nonsteady Flow. Lu Ting. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 351, 352, illus. 4 references.

INTERNAL FLOW

Pressure Losses Across Screens and Grids. S. F. Hoerner. *U.S., Air Force, Technical Report No. 6289*, November, 1950. 22 pp., illus. 11 references.

A review of theoretical and experimental work on screens and grids which presents findings on aerodynamic parameters, pressure-drag losses of wire screens, of slender elements, and of sharp-edged elements, diffuser and inclined and staggered grids, and on the effects of compressibility.

Supersonic Flow Through Nozzles with Rotational Symmetry. Yu Why Chen. *Communications on Pure and Applied Mathematics*, Vol. 5, No. 1, February, 1952, pp. 57–86, illus. 11 references.

A theoretical solution for three-dimensional, steady, supersonic flow with cylindrical symmetry in the neighborhood of the axis. The solution assumes that the states of flow are given along two characteristics $C-$ (backward) and $C+$ (forward) which issue from a point on the axis of symmetry.

Notes on Gas Flow Through a Nozzle. A. M. Binnie. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 3, July, 1950, pp. 492–499, illus. 9 references. Oscillations in a straight divergent nozzle; calculation of nozzle throat velocities.

Readers' Forum: Design of Nozzles Having Continuous Wall Curvature. J. C. Crown. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 358, 359, illus. 2 references.

PARASITIC COMPONENTS & INTERFERENCE

Supersonic Wing-Body-Tail Interference. George Morikawa. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 333–340, illus. 5 references.

Analysis, using stationary linearized theory, of the aerodynamics of the wing-body-tail interference for an in-line configuration that consists of a semi-infinitely long circular cylinder, a delta wing, and a delta tail with no afterbody, at an angle of incidence near zero.

Design of Wing Junction, Fuselage, and Nacelles To Obtain the Full Benefit of Sweptback Wings at High Mach Number. D. Küchemann. *Gt. Brit., Royal Aircraft Establishment, Report No. Aero. 2219*, August, 1947. 68 pp., illus. 18 references.

Approximate theoretical calculations of the flow at zero lift at the junction of swept wings and of the interference effects due to fuselage and nacelles. A simple formula is developed for velocity distribution at the center section of a swept wing that permits modification of the profile section at the center section.

Design of Wing Junction, Fuselage, and Nacelles to Obtain The Full Benefit of Sweptback Wings at High Mach Number. Addendum: Additional Tables of Coefficients. J. Weber. *Gt. Brit., Royal Aircraft Establishment, Report No. Aero. 2219a*, May, 1949. 14 pp. 1 reference.

PERFORMANCE

The Rate of Climb of Turbo-Jet Aircraft. D. C. Whitteley. *Aircraft Engineering*, Vol. 24, No. 276, February, 1952, pp. 45–47, illus. 1 reference.

A method of analyzing climb data to establish the climb performance of an aircraft. Four or five climbs to altitude are required at a given r.p.m. covering a speed range sufficient to establish the speed for best rate-of-climb. The data is corrected for aircraft, engine, and atmospheric conditions, leading to a final result that corresponds to an operational climb to altitude.

WINGS & AIRFOILS

Research Work on Lifting Plane Theory. V. M. Falkner. Teddington, Middlesex, England, October, 1951. 8 pp. 54 references. Summary of the work on lifting plane theory which has been done by the author and his associates; scope of their general program of study; list of published material.

A Generalization of Prandtl's Equation. A. van Heemert. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. F.76 (Verslagen en Verhandelingen*, Vol. 16, pp. F45–F66), 1951. 22 pp., illus. 11 references.

Derivation of generalizations of Prandtl's equation which apply to straight wings of high aspect ratio in yaw and to symmetric sweptback wings. The resulting equations express the downwash at the surface, based on the assumption of suitable expressions for spanwise components of the vorticity distribution.

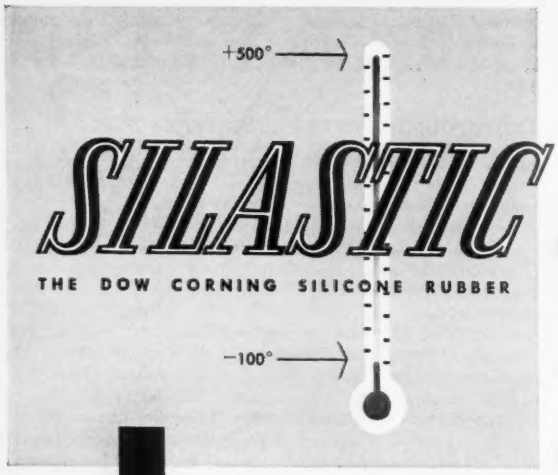
The Measurement of Downwash and Sidewash Behind a Rectangular Wing at a Mach Number of 1.6. Theodore Davis. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 329–332, 340, illus. 3 references.

Some Remarks on an Approximate Method of Estimating the Wave Drag Due to Thickness at Supersonic Speeds of Three-Dimensional Wings with Arbitrary Profile. Kenneth Margolis. *U.S., N.A.C.A., Technical Note No. 2619*, February, 1952. 9 pp. 14 references.

Derivation of a semiempirical profile-correction factor that uses previously calculated drag coefficients for estimating the wave drag due to thickness at supersonic speeds for three-dimensional wings of arbitrary airfoil section; comparison with theoretical values.

Comparison of Supersonic Minimum-Drag Airfoils Determined by Linear and Nonlinear Theory. E. B. Klunker and Keith C. Harder. *U.S., N.A.C.A., Technical Note No. 2623*, February, 1952. 19 pp., illus. 4 references.

A comparison of the section shapes for minimum pressure drag determined by linear and nonlinear theory in order to estimate the errors introduced by the linearized form of the pressure coefficients and to determine its range of validity for this type of calculation.



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Here are just three examples of how Silastic is being used to improve products and to cut production and maintenance costs.

Such applications are practical because Silastic is the only kind of rubbery material that retains its physical and dielectric properties at temperature extremes ranging from —100° to over 500°F. It is most serviceable as a gasketing material at both high and low temperatures and in contact with hot oil.

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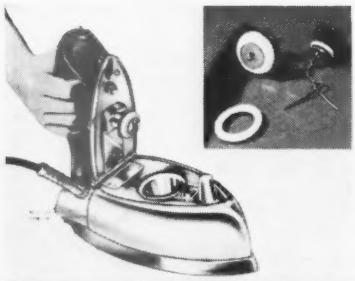
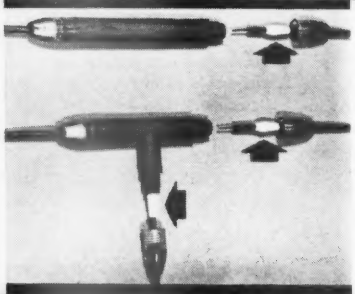


Silastic seals and gaskets are used to seal steam chambers in domestic steam irons because Silastic is insoluble in water, odorless, stainless and resilient at operating temperatures ranging up to 500°F. Life testing and field experience indicate that Silastic seals will retain their resilience for the normal service life of the iron.

Photo courtesy Rival Manufacturing Co.



All connections in aircraft antennae used to be individually spliced and taped. That tedious task has been eliminated, and static and corona discharge have been reduced by as much as 90% through the use of "Anstat" fittings equipped with Silastic seals. These seals retain their dielectric properties and exclude moisture and dust after long exposure to outdoor weathering and to the full range of ground and stratospheric temperatures.

Photo courtesy Fredric Flader, Inc.

Silastic pads and rollers are frequently used to apply pressure in heat sealing equipment. In this machine, for example, a Silastic ring is used to band cosmetic containers with a ribbon of gold leaf. It remains resilient and nonadhesive after long periods of service at surface temperatures above 400°F.

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Two-Dimensional Rotational Flow at High Mach Number Past Thin Aerofoils. F. A. Goldsworthy. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 54–63. 11 references.

Analysis of two-dimensional rotational gas flow past thin airfoils, assuming a free stream Mach Number of approximately 5 and maximum stream deflection of the wing of about 5–10°; review of previous work. A general similitude is established which states that the problem of determining the two-dimensional flow at a high Mach Number past a thin airfoil is in the limit analytically identical with that of unsteady one-dimensional flow produced by the movement of a piston. The error involved is determined, and the effect of entropy is studied briefly.

The Direct Use of Green's Method for Supersonic Potentials. J. O'Keeffe. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 82–92. 2 references.

Construction of a simple and direct solution of the problem of steady supersonic flow over a thin wing at zero incidence by methods analogous to Green's methods. The solution avoids any use of Hadamard's theory of the finite part of an improper integral.

Supersonic Flow over an Inclined Wing of Zero Aspect Ratio. K. Stewartson. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 2, April, 1950, pp. 307–315, illus. 3 references.

Aeroelasticity

An Experimental Investigation of Gust Loads on an Airfoil at High Subsonic Airspeeds. Robert A. Holdahl. **Appendix.** B. M. Leadon. *Minnesota, University, Institute of Technology, Department of Aeronautical Engineering, Research Report No. 69*, November 1, 1950. 64 pp., illus. 6 references.

An investigation in which the penetration of a gust was simulated in a wind tunnel by rapidly rotating an NACA 64A012 airfoil of 3.25-in. chord through a small angle of attack in a steady stream. Results are given for a series of tests conducted at M = 0.5 and R = 2.9×10^6. The appendix covers an analysis of the transient lift resulting from the rapid pitching rotation of a flat plate in two-dimensional compressible flow.

Summary of Acceleration and Airspeed Data from Commercial Transport Airplanes During the Period from 1933 to 1945. Walter G. Walker and Roy Steiner. *U.S., N.A.C.A., Technical Note No. 2625*, February, 1952. 30 pp., illus. 13 references.

A summary of normal acceleration and airspeed data collected with N.A.C.A. V-g recorders on transport aircraft from 1933 to 1945. The data are analyzed with respect to gusts and gust loads.

An Approximate Theory of the Oscillating Wing in a Compressible Subsonic Flow for Low Frequencies. J. R. M. Radok. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. F.97*, September 14, 1951. 15 pp., illus., folding chart. 5 references.

Development of an approximate theory for a thin two-dimensional airfoil oscillating at low frequency in compressible subsonic flow. The method is analogous for the unsteady problem to the Prandtl-Glauert transformation of the steady problem.

The Oscillating Wing in a Subsonic Flow. *Netherlands, Mathematisch Centrum, Amsterdam, Report No. R 53, Int. 1–8*, 1949–1951. 182 pp., illus., tables. 3 references. Mathematical theory and computations. Data sheets give results of computations for the various parameters involved.

Readers' Forum: Comments on "Aerodynamic Coefficients of an Oscillating Airfoil in Two-Dimensional Subsonic Flow" by R. Timman, A. I. van de Vooren, and J. H. Greidanus. Henry E. Fettis. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 353, 354, illus. 5 references.

An Investigation of the Effect of a Varying Tip-Weight Distribution on the Flutter Characteristics of a Straight Wing. William H. Gayman. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 289–301, illus. 2 references.

Summary of tests on a flutter model on the Northrop Scorpion F-89 wing with integral tip fuel pod in which approximately 300 pod mass configurations with six tips pods varying in size and shape were tested; progress of the analytical approach to the flutter problem.

Determination of Indicial Lift and Moment of a Two-Dimensional Pitching Airfoil at Subsonic Mach Numbers from Oscillatory Coefficients with Numerical Calculations for a Mach Number of 0.7. Bernard Mazelsky. *U.S., N.A.C.A., Technical Note No. 2613*, February, 1952. 30 pp., illus. 10 references.

Readers' Forum: Correction for Aspect Ratio of the Indicial Lift Functions of Wagner and Küssner. R. H. Scanlan. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 357, 358. 6 references.

Readers' Forum: The Superposition of High-Intensity Periodic Waves on a Steady Flow. J. C. Truman and N. J. Lipstein. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 354, 355, illus. 4 references.

Readers' Forum: The Reverse-Flow Theorem for Nonstationary Flows. A. H. Flax. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 352, 353. 9 references. Derivation of a proof of the reverse-flow theorem for nonsteady flows.

Air Transportation (41)

It's Quicker by Post. Tony Cole. *The Aeroplane*, Vol. 82, No. 2121, March 14, 1952, pp. 299, 300, 301, 304, illus.

Development and operation of Belgium's helicopter postal service that uses two Bell 47D helicopters and regularly covers a circuit of 230 miles with an efficiency of 95 per cent.

A Guide to Air Shipping via the Port of New York. *Port of New York Authority, Department of Aviation Development*, March, 1952. 35 pp., illus. Economics and mechanics of routing air cargo through the Port of New York from inland; problems involved; tables of rates and specific shipping data.

Economic Developments in Air Transportation and Their Implications. Oswald Ryan. *Talk delivered before the Aero Club of Washington*, February 26, 1952. 13 pp.

The British Independent Operators. *The Aeroplane*, Vol. 82, No. 2121, March 14, 1952, pp. 305–309, illus. A directory of the independently operated British airlines, with a short summary of the development and prospects of each.

Airplane Design (10)

AIR CONDITIONING & PRESSURIZATION

Cabin Pressure Control. E. J. Everson. *Society of Licensed Aircraft Engineers, Journal*, Vol. 1, No. 1, January, 1952 (*Technical Instructor*, Vol. 7, No. 1), pp. 14, 15. Cabin pressure buildup as aircraft reaches optimum flight altitude; calculation of maximum rate-of-change of cabin pressure.

Stress Problems in Pressurized Cabins. W. Flügge. *U.S., N.A.C.A., Technical Note No. 2612*, February, 1952. 91 pp., illus. 11 references. Theory and data for use in the design of pressurized aircraft cabins or similar lightweight pressure vessels.

AIRPLANE DESCRIPTIONS

Know Your Bombers. *Interavia*, Vol. 7, No. 3, March, 1952, pp. 132–137, illus. Photographs and specifications of U.S. and foreign bombers.

The Future Evolution of the Bomber. Eugen Sänger. *Interavia*, Vol. 7, No. 3, March, 1952, pp. 139–143, illus.

Review of the material and intellectual resources of nations which can be applied to technical progress; stages in the technical development of aircraft, based on their power-plant type; evolution of the rocket bomber.

Aero Commander 520 High-Wing Twin-Engined 5-Place Aircraft. *Flight Magazine*, Vol. 37, No. 3, March, 1952, pp. 14–17, 32, 38, illus.

Bristol 175 Britannia Four-Engined Turboprop Transport Aircraft, England. *Aviation Week*, Vol. 56, No. 12, March 24, 1952, pp. 21, 22, 25, 26, 28, illus.; *The Engineer*, Vol. 193, No. 5016, March 14, 1952, pp. 366–368, illus. Construction details; specifications; development testing using a nonflying prototype.

Chance Vought AU-1 Corsair Single-Engined Fighter Aircraft. *Aviation Week*, Vol. 56, No. 14, April 7, 1952, pp. 32, 35, illus. A heavily armored ground-support version of the Corsair, equipped with a single-stage Pratt & Whitney R-2800-83W reciprocating engine.

Chance Vought F7A Cutlass Twin-Engined Turbojet Carrier-Based Fighter Aircraft. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 26–32, illus.

Dauby Equipment Co. Bi-Navion Twin-Engined Light Aircraft. *Aviation Week*, Vol. 56, No. 13, March 31, 1952, pp. 28, 31, 32, illus.

Specifications, construction, and advantages in economy of the Bi-Navion, which has a standard Navion frame equipped with two Piper Pacer power plants; the design was developed for both executive transport and field service test work.

de Havilland D.H. 106 Comet Four-Engined Turbojet Transport Aircraft, England. *Aero Research Technical Notes, Bulletin No. 110*, February, 1952. 8 pp., illus. Use of Redux metal-to-metal bonding in constructing the Comet.

Douglas DC-6B Four-Engined Transport Aircraft. Aviation Week, Vol. 56, No. 14, April, 1952, pp. 50, 53, 54, 55, 56, illus.

Performance, equipment, and cockpit instrumentation of P.A.A.'s DC-6B's for tourist service.

Fairchild C-119H Twin-Engined Cargo Aircraft. *American Aviation*, Vol. 15, No. 45, May 12, 1952, pp. 24, 25, illus.

FIAT G 80 Single-Engined Turboprop Trainer-Fighter Aircraft, Italy. *Aircraft Engineering*, Vol. 24, No. 277, March, 1952, pp. 72–75, illus.

North American XA2J-1 Savage Twin-Engined Turboprop Bomber Aircraft. *Aero Digest*, Vol. 64, No. 2, February, 1952, pp. 20–27, illus.

Piper PA-18-A Single-Engined Agricultural Aircraft. *Aviation Age*, Vol. 17, No. 3, March, 1952, pp. 111–118, illus.

Republic F-84F Single-Engined Turbojet Fighter-Bomber Aircraft and RF-84F Single-Engined Turbojet Photo-Reconnaissance Aircraft. *Aviation Week*, Vol. 56, No. 14, April 7, 1952, pp. 16, 17, illus.

S.N.C.A.S.O. SO. 30P. Twin-Engined Transport Aircraft, France. *Indian Skyways*, Vol. 6, No. 1, January, 1952, pp. 22, 23, illus.

Tu-75 (or TuG-75) Six-Engined Turboprop Swept-Wing Bomber Aircraft, U.S.S.R. *Interavia*, Vol. 7, No. 3, March, 1952, p. 138, illus.

BODY GROUP

The Analysis of Fuselage Frames. II. William Morse. *Aircraft Engineering*, Vol. 24, No. 277, March, 1952, pp. 76–80, 88, illus. Solution by the elastic center method of problems in the design of built-in frames and complete fuselage rings.

COCKPIT & CONTROL CABIN

Functional Cockpit Design. Barry G. King. *Aeronautical Engineering Review*, Vol. 11, No. 6, June, 1952, pp. 32–40, illus. 16 references.

Application of biological data, such as size of vision field, eye level, body stability, and weight, to the functional design of aircraft cockpits; criteria for satisfactory and safe cockpits.

FUEL TANKS

First Commercial Transport Tip Tank Readied. *American Aviation*, Vol. 15, No. 43, April 14, 1952, p. 23, illus.

Design and advantages of 600-gal. tip tank for the turboprop version of the Lockheed Super Constellation; results of flight tests with tip tanks installed on the prototype of the Model 1049 piston-engined Super Constellation.

How New Fuel Tank Sealer Works. George L. Christian. *Aviation Week*, Vol. 56, No. 12, March 24, 1952, pp. 61, 62, illus.

Development and advantages of the Chan-O-Seal method for sealing fuel tanks, pressurized cabins, high altitude aircraft gear, and water-tight hulls and of the Lock-O-Seal method for bolts and rivets.

OPERATION & PERFORMANCE

The Turbo-Prop Airplane. William W. Fox. *Aeronautical Engineering Review*, Vol. 11, No. 6, June, 1952, pp. 22–25, illus. 9 references. Operating experience of Convair with the turbo-prop powered airplane; maintenance problems.

de Havilland D. H. 106 Comet Four-Engined Turbojet Transport Aircraft, England. *Aviation Week*, Vol. 56, No. 10, March 10, 1952, pp. 30, 32, 35, 36, 37, illus.

North American Texan T-6D Trainer Aircraft. N. D. Bray and E. A. Bernard. *Canada, Royal Canadian Air Force, Central Experimental and Proving Establishment, Rockcliffe, Report No. 981*, February, 1952. 16 pp., illus. Handling characteristics.

Saab Scandia Twin-Engined Transport Aircraft, Sweden. *Saab Sonics*, No. 16, Winter, 1951–1952, pp. 6–11, 20, illus. Organization, procedure, and statistics for the maintenance of the Scandia by Scandinavian Airlines System, Norway Region.

Saab J29 Single-Engined Turbojet Fighter Aircraft, Sweden. Percy Silfverberg. *Saab Sonics*, No. 16, Winter, 1951–1952, pp. 14, 15, 25, illus.

WING GROUP

An Investigation of the Effect of a Varying Tip-Weight Distribution on the Flutter Characteristics of a Straight Wing. William H. Gayman. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 289–301, illus. 2 references. Summary of tests on a flutter model of the Northrop Scorpion F-89 wing with integral tip fuel pods.

Airports (39)

An Evaluation of the Traffic Capacity of a Fixed-Block Traffic-Control System in the Approach Zone. W. R. Rambo and R. C. Wheeler, Jr. *Airborne Instruments Laboratory, Inc., Project No. 514H (ATA-2)*, July 15, 1947. 80 pp., illus. 4 references.

Terminal Air-Traffic Control. E. A. Whiteley. *Flight*, Vol. 61, No. 2253, March 28, 1952, pp. 349, 350, illus. (Based on a lecture: The Spacing of Aircraft Under High-Density Approach Conditions, given before the R.Ae.S., March 20, 1952.)

Rotor Stations—Public User View. W. H. Primrose. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1, April–June, 1951, pp. 242–245, Discussion, pp. 245–257. Passenger requirements for comfort, convenience, and efficient traffic handling for helicopter stations.

Rotor Stations—The Scheduled Operator's Viewpoint. R. H. Whitby. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1, April–June, 1951, pp. 227–236, Discussion, pp. 245–257, illus. 3 references.

The scheduled helicopter operator's requirements for station location, size, layout, parking space, servicing facilities, navigation aids, and passenger traffic facilities.

Rotor Stations—Some Architectural and Engineering Aspects. R. S. Colquhoun. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1, April–June, 1951, pp. 239–242, Discussion, pp. 245–257. Design implications and evaluation of ground-level, roof-top, bridge-platform (for cities on a large river), and flexible-pontoon types of rotor stations.

Sites for Rotor Stations—Some Town Planning Considerations. F. H. Littler. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1, April–June, 1951, pp. 237–239, Discussion, pp. 245–257. Problems in locating a helicopter station in the center of a large town.

Aviation Medicine (19)

Aeromedicine: The Dominant Science. Edward J. Kendricks. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 72–80, 82–90, illus.

Scope of aeromedical research; coordination of aeromedicine with the development of high-speed, high-altitude aircraft; development of protective clothing and equipment; human engineering; role of the flight surgeon.

An Apparatus for the Study of the Human Operator. C. E. Warren, P. M. Fitts, and J. R. Clark. *Electrical Engineering*, Vol. 71, No. 3, March, 1952, p. 220, illus. An electronic pursuit apparatus that provides quantitative data on the behavior of a human being functioning as an element of a closed-loop control system.

Fitting Machines to Men. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 164–167, illus. Analysis of machine and control-indicator models to determine optimum mechanical characteristics for efficient operation by humans.

Functional Cockpit Design. Barry G. King. *Aeronautical Engineering Review*, Vol. 11, No. 6, June, 1952, pp. 32–40, illus. 16 references. Application of biological data on pilot vision, eye level, body stability, and weight to the functional design of aircraft cockpits.

Hypoxia Warning Device Flashes Automatic Danger Signal. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 17, No. 3, March, 1952, p. 6, illus.

Computers & Simulators

A Direct-Current Network Analyzer for Solving Wave-Equation Boundary-Value Problems. George W. Swenson, Jr., and

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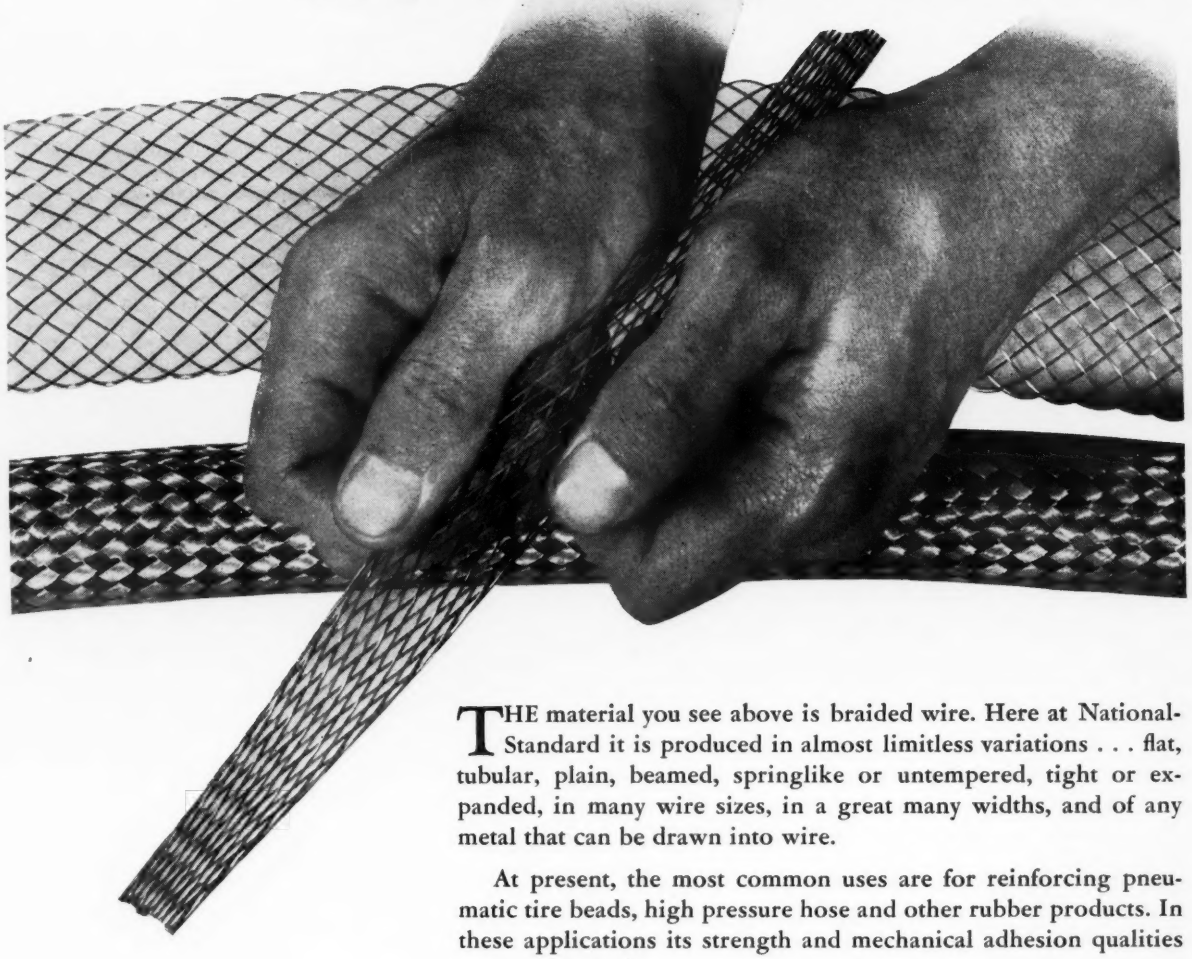

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Thomas J. Higgins. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 126–131, illus. 8 references. Theory, construction, and operation of a d.c. network analyzer for solving the difference equations of wave-equation boundary-value problems.

Some Limitations on the Accuracy of Electronic Differential Analyzers. A. B. MacNee. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 303–308, illus. 10 references.

Air Force B-50D Flight Simulator. M. Berry. *American Helicopter*, Vol. 25, No. 3, February, 1952, pp. 12–14, illus. Instruments and training methods used with flight simulator for the Boeing B-50D bomber.

Education & Training (38)

Training C-124A Crews. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 17–19, illus. U.S.A.F. requirements and training program for aircrews and maintenance crews to operate the Douglas C-124A Globemaster.

Air Force B-50D Flight Simulator. M. Berry. *American Helicopter*, Vol. 25, No. 3, February, 1952, pp. 12–14, illus. Instruments and training methods used with flight simulator for the Boeing B-50D bomber; comparison with other U.S.A.F. trainers.

Electronics (3)

ANTENNAS

Radiation Patterns and Conductance of Slotted-Cylinder Antennas. Obed C. Haycock and Frank L. Wiley. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 349–352, illus. 8 references.

Theoretical method for calculating the conductance and radiation patterns of an antenna that consists of a narrow slot cut in the wall of a hollow circular cylinder of infinite conductivity.

An Experimental Investigation of the Dielectric Rod Antenna of Circular Cross Section Excited in Rotationally Symmetrical Modes. C. M. McKinney. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 11–13, illus. 5 references. Measurements of the radiation patterns for three series of dielectric rod antennas excited in the TM_{01} mode at a frequency of 9,275 mc.

Antenna Gain by Graphical Means. M. W. Scheldorf. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 144–147, illus. 3 references.

A graphic method of calculating antenna gain based on a simple integration of the energy radiated from the antenna; application to complex antennas and to the acoustical gain of loudspeakers and horns.

A Dipole with a Tuned Parasitic Radiator. Ronold King. (*I.E.E., Radio Section, Paper No. 1223.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 99, No. 57, January, 1952, pp. 6–14, illus. 13 references.

Approximate second-order self- and mutual-impedances are used to determine the electric field, the front-back ratio, and the input impedance of an antenna with a single, tuned, parasitic radiator at constant power; theoretical curves are compared with those derived from experiments.

Electromagnetic Resonant Behavior of a Confocal Spheroidal Cavity System in the Microwave Region. J. C. Simons and J. C. Slater. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 29, 30. 4 references.

An investigation of the resonance of a small spheroidal object, approximating the case of a thin needle-like antenna, in a large spheroidal cavity and of the practicality of using this resonance property in measuring the surface impedance of the material of which the needle is composed.

CIRCUITS & COMPONENTS

Introduction to Formal Realizability Theory. I. Brockway McMillan. *Bell System Technical Journal*, Vol. 31, No. 2, March, 1952, pp. 217–279, illus. 14 references. General approach to the realizability theory of networks with many accessible terminals.

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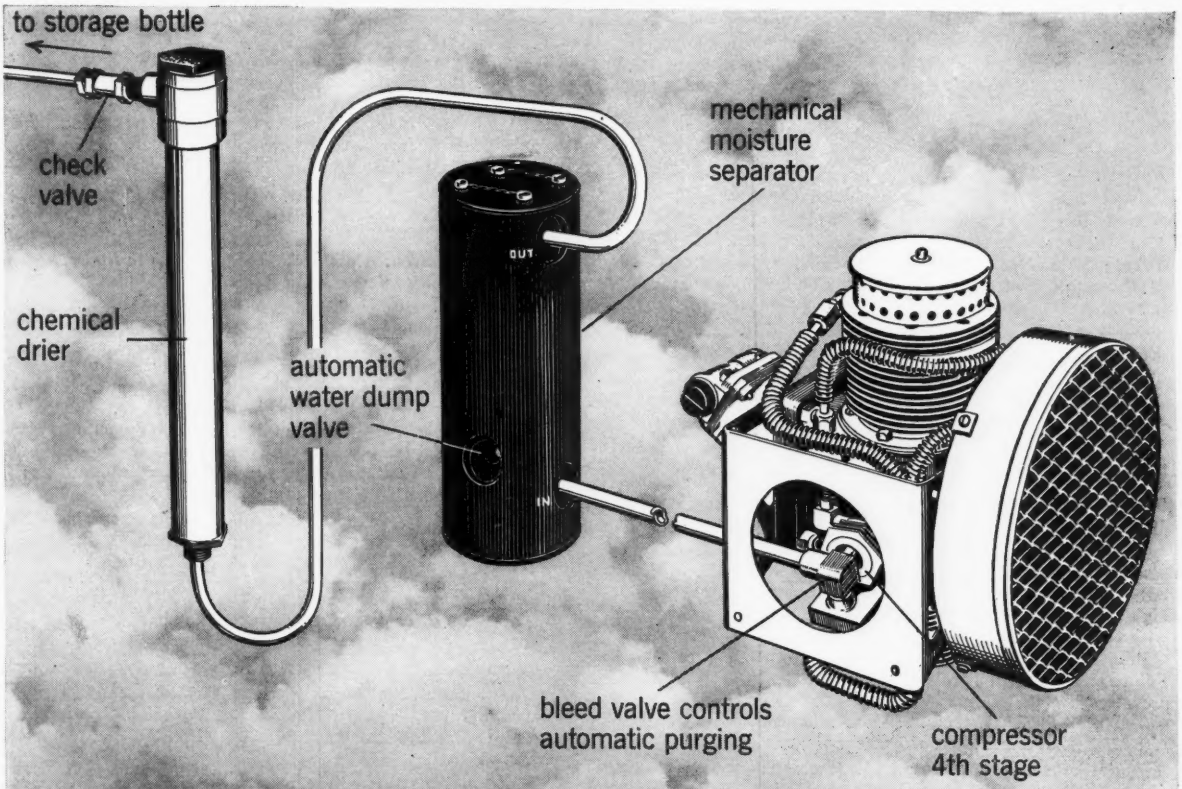

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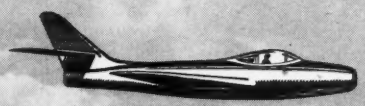

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Accurate Phase Difference by Lissajous Figures. John L. Glaser. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 206, 210, 214, 218, 222, illus. 3 references.

Network Representation of Transcendental Impedance Functions. M. K. Zinn. *Bell System Technical Journal*, Vol. 31, No. 2, March, 1952, pp. 378–404, illus. 12 references.

Résumé of Maxwell's and Kirchhoff's Rules for Network Analysis. Y. H. Ku. *Franklin Institute, Journal*, Vol. 253, No. 3, March, 1952, pp. 211–224, illus. 20 references.

Analysis of Distortion in Pulse-Code Modulation Systems. J. P. Schouten and H. W. F. van't Groenewout. *Applied Scientific Research; Section B, Electrophysics, Acoustics, Optics, Mathematical Methods*, Vol. 2, No. 4, 1952, pp. 277–290, illus. 4 references. General analysis of the distortion caused by the quantization of the amplitude of the input signal.

Circuit Stability in Guided Missiles. R. L. Kelly. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 133–135, illus.

Proper circuit design that controls such factors as grid emission, variation in contact potential, heater-cathode leakage, and shock and vibration dangers results in maximum circuit overall reliability.

The Design of Series-Parallel Valve Voltage Stabilizers. F. A. Benson. *Electronic Engineering*, Vol. 24, No. 289, March, 1952, pp. 118, 119, illus. 15 references.

The L-Cathode Structure. G. A. Espersen. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 284–289, illus. 1 reference. Basic features of the L cathode, a high-emission density thermionic emission cathode; comparison with three common types of emitters.

Proposed Revision of the Conventional Method of Wave-Filter Design. Paul J. Selgin. *U.S., National Bureau of Standards, Journal of Research*, Vol. 47, No. 6, December, 1951, pp. 479–490, illus. 7 references. (Also available as *Research Paper No. 2276*. Superintendent of Documents, Washington. $0.10.)

Radio-Frequency Oscillators. J. James Ebers. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 21–31, illus. 3 references. A 4–8 cm. retarding-field oscillator.

An Amplitude Comparator Multivibrator. S. Fedida. *Marconi Review*, Vol. 15, No. 104, 1st Quarter, 1952, pp. 35–43, illus.

Theory and construction of a multivibrator circuit in which the multivibrator output pulse, waveform, amplitude, delay, etc., and the recovery time are independent of the input pulse amplitude. This independence is obtained by using a double diode suitably connected in a subsidiary feed-back loop in the multivibrator circuit.

Proper Use of By-Pass Condensers. *Aerovox Research Worker*, Vol. 22, No. 3, March, 1952, pp. 1–3, illus.

Low-Field Magnetrons. John L. Moll. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 36–44, 54, 55, illus. 3 references. A study of the operating characteristics of magnetrons at low magnetic fields, currents, and voltages.

Current Trends in Fixed Resistors. Philip S. Schmidt. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 124–129, illus. Design and operation of resistors that were developed for applications requiring temperature ranges from −65° to 200° C., miniaturization, and low cost.

Klystron Circuits. A. E. Harrison. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 148, 150, illus.

Ferrite Applications in Electronic Components. B. V. Vonderschmitt, M. J. Obert, and H. B. Stott. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 138, 139, illus.

CONSTRUCTION TECHNIQUES

How to Keep Cool and Lose Weight. Philip Klass. *Aviation Week*, Vol. 56, No. 11, March 17, 1952, pp. 41, 42, illus.

A technique of turbulent airflow cooling for aircraft equipment developed at Raytheon which obtains a heat transfer efficiency of 70 per cent and a weight cut of 50 per cent by moving outside air through metal tubes at a Reynolds Number considerably in excess of 2,300.

IRE Talks Point to Weight Saving. Philip Klass. *Aviation Week*, Vol. 56, No. 12, March 24, 1952, pp. 35, 36, 38, 40, 43, 44, 46, illus.

New techniques and ideas for reducing the size, weight, and complexity of high-speed aircraft electronic units, for increasing their reliability, for applying the transistors to electronics equipment.

Etching—A General Fabrication Technique. W. H. Hannahs and J. A. Caffiaux. *Radio & Television News*, Vol. 47, No. 3, March, 1952, *Radio-Electronic Engineering*, pp. 7–9, 31, illus. Three methods of producing an electrical connective harness and components by the selective etching of copper foils bonded to plastic laminates.

ELECTRONIC TUBES

The Charactron. Joseph T. McNaney. (*Institute of Radio Engineers, National Convention, New York*, March 3–6, 1952.) *Consolidated Vultee Aircraft Corp.*, March, 1952. 12 pp., illus.

Design and operation of a cathode-ray tube that displays data from high-speed communications systems and high-speed computers 1,000 times faster than present mechanical methods; components; message codes; charactron high-speed printer. A beam-forming matrix that is located between the electron gun and the fluorescent screen contains letter or numeral openings through which an electron beam is passed. The shaped beam is deflected to the desired point on the screen, thus translating input signals into visual intelligence.

The Travelling-Wave Valve As a Microwave Phase-Modulator and Frequency-Shifter. W. J. Bray. (*I.E.E., Radio Section, Paper No. 1216.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 99, No. 57, January, 1952, pp. 15–20, illus. 5 references.

Development of the principles of the traveling-wave tube when used as a phase-modulator and frequency-shifter; possible applications in transmitters and repeaters of radio relay systems.

Thermal and Shot Fluctuations in Electrical Conductors and Vacuum Tubes. Salim S. Solomon. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 109–112, illus. 9 references.

Electron-Tube Curve Generator. M. L. Kuder. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 118–124, illus.

Performance characteristics, circuits, and operation of an electron-tube curve generator that automatically displays, on a cathode-ray screen, the complete static plate characteristics, locus of the load, and coordinates for direct measurement. Receiving tubes can be analyzed with an accuracy of ±5 per cent using a Land camera.

High-Frequency Tubes. John L. Moll. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 12–20, 54, illus. Scaling; laboratory testing; the retarding-field oscillator in the 2–4 cm. range.

Crystal Diodes in Modern Electronics. VI. David T. Armstrong. *Radio & Television News*, Vol. 47, No. 3, March, 1952, pp. 56, 57, 127, 128, illus.

Cathode-Ray Tube for Recording High-Speed Transients. S. T. Smith, R. V. Talbot, and C. H. Smith, Jr. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 297–302, illus. 11 references. Design considerations and physical description of a traveling-wave cathode-ray tube that will record single nonrecurrent transients of 0.5 millimicrosec. rise time.

Discussion on "Correction of Deflection Defocusing in Cathode Ray Tubes" by J. E. Rosenthal. R. G. E. Hutter and S. W. Harrison. **Author's Reply.** *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 353–357, illus. 7 references.

The (Ohio State) Electron Tube Laboratory and Its Research Program. E. M. Boone. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 3–11, illus.

Materials and Shop Techniques for Electron Tube Research. John Cowan. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 45–47, 55, illus. 4 references.

Glass Tube Technology. Peter Whibley. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 48–52, illus. Glass-to-metal seals; pumping of vacuum tubes.

Metals, Ceramics, and Seals Used in Vacuum Tubes. Stanley Taylor. *Ohio, State University, Engineering Experiment Station, News*, Vol. 23, No. 5, December, 1951, pp. 52, 53.

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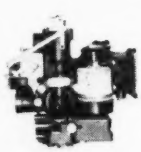

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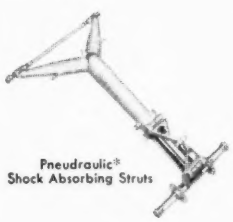

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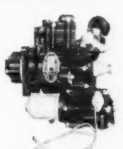

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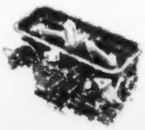

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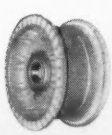

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MEASUREMENTS & TESTING

Wave Guide Calorimeter. Samuel Freedman. *Radio & Television News*, Vol. 47, No. 3, March, 1952, *Radio-Electronic Engineering*, pp. 10–12, 29, 30, illus.

Review of calorimeter design and principles of operation of early units; design details and evaluation of the TPC-Kahl calorimeter that accurately measures microwave power, regardless of waveform or duty cycle.

Two Bridges for Measuring Valve Parameters. G. Smith. *Electronic Engineering*, Vol. 24, No. 289, March, 1952, pp. 127–129, illus.

Two bridges, one for measuring mutual conductance and one for measuring anode impedance and amplification factor of a triode or pentode within 3 per cent; bridge balance equations. The bridges permit the use of a power pack without having to consider its impedance or its capacitance to earth.

A 1-Megacycle Schering Bridge. Ivan G. Easton. *General Radio Experimenter*, Vol. 26, No. 9, February, 1952, pp. 4–8, illus. 2 references. Design, construction, and operation of the General Radio Type 716-CS1 Schering bridge for measuring capacitance and dissipation factors at a frequency of one mc. and for dielectric measurements.

A Note on a Selective RC Bridge. Peter G. Sulzer. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 338, 339, illus. 4 references.

A simple resistance-capacitance bridge in the form of a generalized six-arm bridge; it provides a moderate increase in selectivity without requiring an increase in the number of circuit elements.

Automatic Equipment for Resistor Load-Life Tests. *U.S., National Bureau of Standards, Summary Technical Report No. 1647*, March, 1952. 4 pp.

An Apparatus for the Study of the Human Operator. C. E. Warren, P. M. Fitts, and J. R. Clark. *Electrical Engineering*, Vol. 71, No. 3, March, 1952, p. 22, illus.

Block diagrams and operation of an electronic pursuit apparatus that automatically provides several scores of human performance, such as mean error, mean-square error, and time-on-target scores for three different error bandwidths.

NAVIGATION AIDS

Omni-Ranges for Long Distance Navigation. Ernst Kramar and C. Lorenz. *Interavia*, Vol. 7, No. 3, March, 1952, pp. 159–162, illus. 6 references. Accuracy, reliability, and simplicity of omnirange navigation systems; equipment needed in the aircraft for long-distance omnirange navigation.

Air Navigation—Present and Future. I, II, III. Richard E. Stockwell. *Aviation Age*, Vol. 17, No. 3, March, 1952, pp. 37–69.

A survey of U.S. air navigation systems, instruments, procedures, and possible developments. A directory gives the names and addresses of the companies producing new navigation aids and a brief description of the products.

United States Omnirange Stations. *Aviation Age*, Vol. 17, No. 3, Section 2 (insert), March, 1952. $0.50. A map that presents the locations, station call letters, and frequencies of omnirange facilities in the U.S.

NOISE & INTERFERENCE

Noise Factors of Networks. O. E. Keall. *Marconi Review*, Vol. 15, No. 104, 1st Quarter, 1952, pp. 25–34, illus. 6 references.

Estimation of the noise factor of networks, using normal methods of circuit analysis. Two theorems are developed for the noise factor, one for discontinuous and one for continuous circuits, neglecting the influence of feedback and temperature.

On the Theory of Filtration of Signals. Lotfi A. Zadeh. *Zeitschrift für angewandte Mathematik und Physik*, Vol. 3, No. 2, March 15, 1952, pp. 149–156, illus. 4 references.

Brief outline of a theory of linear variable filters; conditions under which two or more signal groups, each consisting of a message and a noise, can be separated from each other by using linear variable filters.

On the Distribution of Energy in Noise- and Signal-Modulated Waves. II—Simultaneous Amplitude and Angle Modulation. David Middleton. *Quarterly of Applied Mathematics*, Vol. 10, No. 1, April, 1952, pp. 35–56, illus. 4 references.

SATURABLE REACTORS

Some Aspects of Magnetic Amplifier Technique. F. E. Butcher and R. Willheim. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 261–270. 6 references. Design principles for the construction of precision magnetic amplifiers for d.c.—d.c. amplification at relatively low input levels; performance data.

Compensating for Quiescent Current in Multistage Magnetic Amplifiers. A. S. Fitzgerald. *Electrical Engineering*, Vol. 71, No. 3, March, 1952, pp. 206–211, illus. 5 references.

Saturable Reactors. Erwin Levey. *Radio & Television News*, Vol. 47, No. 3, March, 1952, pp. 68, 69, 150, 151, illus. Circuit, construction, and operation of a saturable reactor that uses two separate standard power transformers and can be assembled breadboard style.

TELEMETRY

Simultaneous A-M and F-M in Rocket Telemetering. W. Cullen Moore. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 102–105, illus. 9 references.

Two full-time channels on a single carrier allow transmission of complicated data for which sampling techniques are inadequate; one is a video channel 5 mc. wide used for waveforms and other experimental signals from sounding rockets.

TRANSMISSION LINES

The M.I.T. Linear Electron Accelerator. P. T. Demos, A. F. Kip, and J. C. Slater. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 53–65, illus. 14 references.

Design principles, structural features, and operation of the M.I.T. linear electron accelerator. The accelerator consists of a circular wave guide fitted with uniformly spaced irises; it sustains a standing-wave, transverse magnetic π = mode oscillation at a resonant frequency of 2,800 mc.

Particle Dynamics in the Linear Accelerator. J. R. Terrall and J. C. Slater. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 66–68, illus. 2 references.

Formation of a chart of the final energy and phase of electrons after traversing a section of the accelerator, in terms of initial energy and phase; values in the chart are appropriate for the M.I.T. accelerator.

Field Strength Measurements in Resonant Cavities. L. C. Maier, Jr. and J. C. Slater. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 68–77, illus. 8 references.

Analysis of the field strength measurements in a resonant cavity of complicated shape, using a theorem that gives the change of the resonant frequency of a cavity by a perturbation of its boundaries; proof of the fact that the perturbation theory can be used to measure field strength at an interior point; evaluation of the amount of perturbation.

Determination of Field Strength in a Linear Accelerator Cavity. L. C. Maier, Jr. and J. C. Slater. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 78–83, illus. 5 references.

The Relative Power-Carrying Capacity of High-Frequency Waveguides. H. M. Barlow. (*I.E.E., Radio Section, Paper No. 1225.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 99, No. 57, January, 1952, pp. 21–27, illus. 3 references.

WAVE PROPAGATION

Waves on Inhomogeneous Cylindrical Structures. R. B. Adler. *Institute of Radio Engineers, Proceedings*, Vol. 40, No. 3, March, 1952, pp. 339–348, illus. 9 references.

An analysis of some of the basic properties of exponential modes on passive cylindrical structures in which the material constants of the medium vary over the cross section; each mode is usually a $TE = TM$ mixture.

Equipment

ELECTRIC (16)

Development in Aircraft Power Equipment. J. D. Miner. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 50, 52, 53, illus. Survey of development of generators and motors for aircraft.

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Adjustable Speed Characteristics of D-C Motors. F. A. List. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 180–184, illus. Operating characteristics of shunt-wound, series-wound, and compound-wound d.c. motors as their speeds are varied.

Hermetically Sealed Switches Protect High Flying Aircraft. *CEC Recordings*, Vol. 6, No. 1, March, 1952, p. 7, illus. Leak testing program assures Micro Switch faultless operation.

HYDRAULIC & PNEUMATIC (20)

A New Hydraulic Pump. *The Aeroplane*, Vol. 82, No. 2122, March 21, 1952, p. 336, illus. Design and operation of the two-stage Dowty Vardel pump for general use in aircraft hydraulic circuits with pressures of up to 4,000 lbs. per sq.in.; rate of delivery is 5 gal. per min.

Hydraulic Noise Reduction by Capacitive Load Chamber. G. W. Louthan. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 135–139, illus.

Theory of capacitive loading chambers for hydraulic systems; methods for determining chamber size requirements and the effect of the chambers on the pump pressure waves that cause hydraulic noise and circuit destruction; charts for approximating effective chamber volume.

Hydraulic Maintenance. II—How to Prevent Overheating of Hydraulic Systems. A. R. Morse. *Applied Hydraulics*, Vol. 5, No. 3, March, 1952, pp. 59, 60, 95, illus. Methods and equipment used for cooling oil in hydraulically operated machines.

Application of Pneumatics for Aircraft De-Icing System. *Applied Hydraulics*, Vol. 5, No. 3, March, 1952, pp. 102, 104, illus.

Flight Operating Problems (31)

HIGH-SPEED FLIGHT

High-Speed Flying. John D. Derry. *Indian Airman*, 6th Year, No. 1, January, 1952, pp. 5–12, 22, illus. Piloting techniques.

ICE PREVENTION & REMOVAL

Aircraft Icing Research with the Rockcliffe Ice Wagon. *Canada, National Aeronautical Establishment, Information Circular*, January, 1952. 8 pp., illus.

Instrumentation, personnel, and scope of operations of the R.C.A.F.-N.A.E. Rockcliffe Ice Wagon, a Canadair North Star transport aircraft that is adapted for icing research. Scope of research includes electro-thermal wing and propeller deicing studies and the measurement of cloud properties.

Ice Accretion on Aircraft. *Gt. Brit., Meteorological Office, Meteorological Reports No. 9* (Vol. II, No. 4), 1951. 36 pp., illus. 11 references. British Information Services, New York. $0.50. An analysis of the meteorologic conditions of ice formation and of icing protection and prevention; deicing procedures.

Flight in Ice. I, II. Ross Smyth. *Canadian Aviation*, Vol. 25, Nos. 3, 4, March, April, 1952, pp. 34, 76, 78; 50, 76, 78–84. 11 references.

Data about the formation of ice on aircraft, its effects, precautionary measures, and piloting procedures for flight under icing conditions and for using deicing systems.

Airscrew De-Icing. *Flight*, Vol. 61, No. 2251, March 14, 1952, p. 291, illus. Design, by Rotol, Ltd., of the composite propeller blade that incorporates electric heating elements with each side of the leading edge.

Application of Pneumatics for Aircraft De-Icing System. *Applied Hydraulics*, Vol. 5, No. 3, March, 1952, pp. 102, 104, illus.

Components and operation of the De-Icer system developed jointly by the Navy Bureau of Aeronautics, Douglas Aircraft Co., The B. F. Goodrich Co., and Eclipse-Pioneer Division of Bendix Aviation Corp., for the Douglas AD Skyraider. The system is solenoid operated, incorporates multiple small tubes actuated by twice the conventional air pressure, remains operative at high speeds, and does not disturb the flight characteristics of the aircraft.

WEATHER HAZARDS

Why You Fly Thunderstorms the Way You Do. Patrick J. Harney. *Aero Digest*, Vol. 64, No. 2, February, 1952, pp. 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 99, illus. Piloting procedures for flights through thunderstorms, based on results of meteorological and aeronautical research.

Flight Safety & Rescue (15)

Crashes Spur Action on Prop Reversals. F. Lee Moore. *Aviation Week*, Vol. 56, No. 10, March 10, 1952, pp. 63, 64. Data on in-flight accidental reversals of the propellers of transport aircraft; preventive measures.

Fire-Fighting at Airports. J. L. Jacob. *Interavia*, Vol. 7, No. 3, March, 1952, pp. 162–165, illus. Prevention, detection and warning, and extinguishment of airport fires in buildings and aircraft.

Colonial's "Personal" Path to Safety. George L. Christian. *Aviation Week*, Vol. 56, No. 13, March 31, 1952, pp. 57, 58, illus. Equipment and methods of maintenance and overhaul used by Colonial Airlines for accident reduction; safety record.

Flight Testing (13)

Naval Test-Flying. E. M. Brown. (*Gt. Brit., Admiralty Bulletin No. 38.*) *The Engineer*, Vol. 192, No. 5018, March 28, 1952, p. 435. *Flight*, Vol. 61, No. 2253, March 28, 1952, pp. 358, 359, illus. How acceptance trials are carried out; catapult, rocket, and arrester tests.

Fuels & Lubricants (12)

The Oxidation, Decomposition, Ignition, and Detonation of Fuel Vapors and Gases. XIX—Optimum Timing of Compression or Spark Ignition As Determined by Adjustment of Compression Ratio; Acetaldehyde and Diethyl Ether As Engine Fuels. R. O. King, E. J. Durand, A. B. Allan, and E. J. T. Hansen. *Canadian Journal of Technology*, Vol. 30, Nos. 2 & 3, February-March, 1952, pp. 29–60, illus. 13 references.

Equipment for Use with High-Strength Hydrogen Peroxide. Noah S. Davis, Jr., and John H. Keefe, Jr. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 63–69, illus. 4 references. Results of compatibility tests on various metals, plastics, and lubricants are applied to design techniques and methods of preparing equipment for H_2O_2 service.

Calculation of Adiabatic Decomposition Temperatures of Hydrogen Peroxide Solutions. G. C. Williams, C. N. Satterfield, and H. S. Isbin. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 70–77, illus. 7 references.

Instruments (9)

A Simplified Analysis of Helicopter and Automatic Pilot Dynamic Stability. I. John E. Burkam. *American Helicopter*, Vol. 25, No. 3, February, 1952, pp. 8–10, 14, illus.

PAA's Tourist Cabin, De Luxe Cockpit. Scott H. Reiniger. *Aviation Week*, Vol. 56, No. 14, April 7, 1952, pp. 50, 53, 54, 55, 56, illus.

Details of the complete radio and navigation instrumentation and cockpit layout of P.A.A.'s tourist-service DC-6B transports. The aircraft are equipped with both the Sperry Zero Reader and the Sperry approach coupler, along with other navigation and electronic instruments.

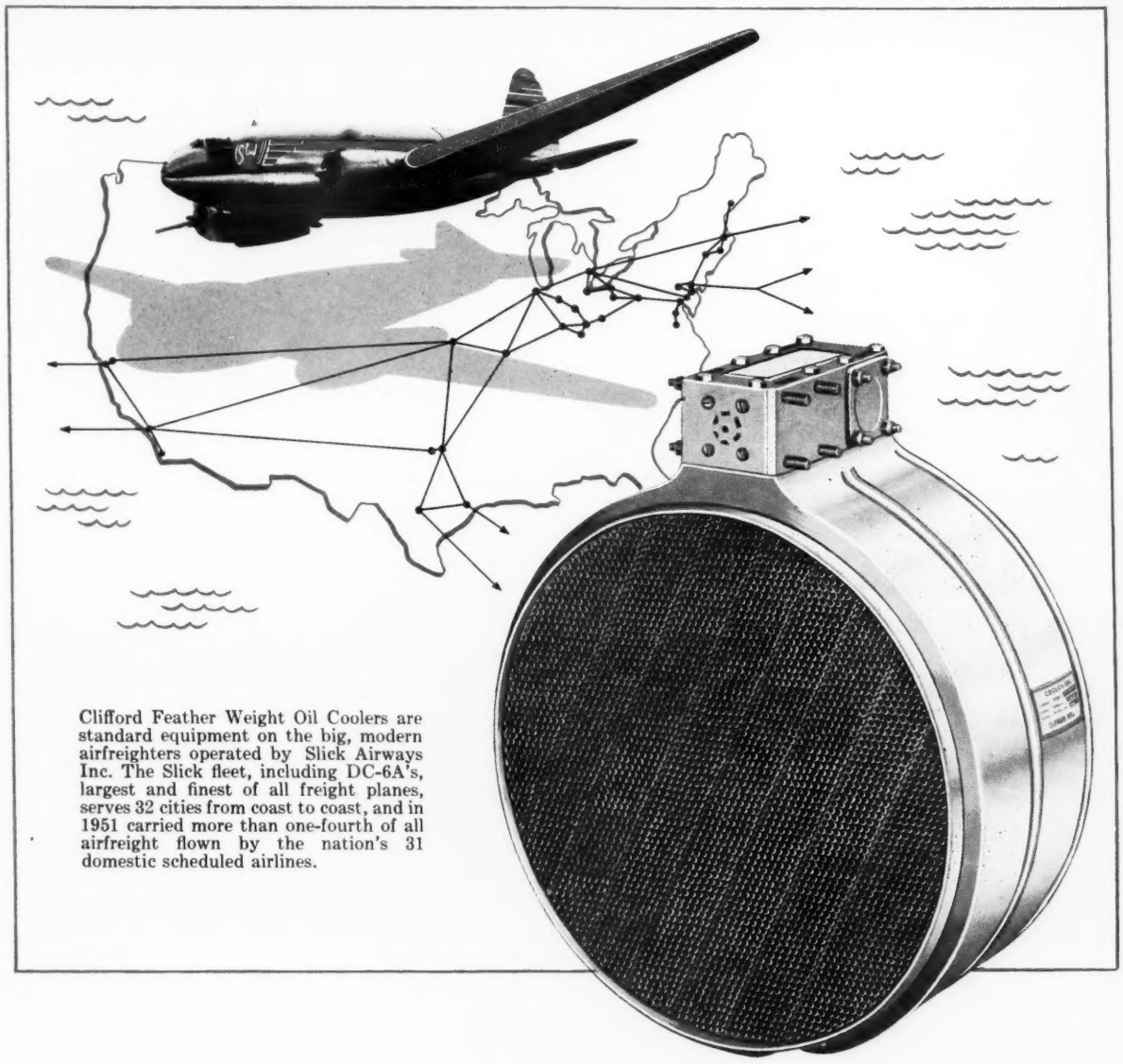
Magnetic Tape Data-Recording Systems. Robert Endall. *Radio & Television News*, Vol. 47, No. 3, March, 1952, *Radio-Electronic Engineering*, pp. 3–6, 30, illus. Advantages and methods of recording information on magnetic tape; types, construction, and operation of systems in which it can be used.

The Charactron. Joseph T. McNaney. (*Institute of Radio Engineers, National Convention, New York*, March 3–6, 1952.) *Consolidated Vultee Aircraft Corp.*, March, 1952. 12 pp., illus.

Design and operation of a cathode-ray tube that displays data from high-speed communications systems and high-speed computers 1,000 times faster than present mechanical methods; components; message codes; operation, printer control circuits, and apparatus of the Charactron-Xerographic printing mechanism that combines electronic and dry photographic techniques to provide high-speed printing on ordinary writing paper; data conversion.

Brown Temperature Recorder with Convair Control. Bill Chana. *Aero Digest*, Vol. 64, No. 7, January, 1952, pp. 70, 71, illus.

Control units developed by Convair for use with the Brown Flight Test Recorder that measures 144 temperatures in a test aircraft at the rate of 1 per sec. The Convair units, consisting of a control panel and new thermocouple switch boxes, permit



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Laws & Regulations (44)

Aeronautical Patent Law. John A. Eubank. *Dickinson Law Review*, Vol. 56, No. 2, January, 1952, pp. 143–157. 19 references.

Civil Air Regulations for Glider Pilots. Paul F. Bikle. *Soaring*, Vol. 16, No. 2, March-April, 1952, pp. 18–20.

Machine Elements (14)

BEARINGS

Influence of Lubricant Viscosity on Operating Temperatures of 75-Millimeter-Bore Cylindrical-Roller Bearing at High Speeds. E. Fred Macks, William J. Anderson, and Zolton N. Nemeth. *U.S., N.A.C.A., Technical Note No. 2636*, February, 1952. 47 pp., illus. 13 references.

A size 215 cylindrical roller bearing in current use in an aircraft gas-turbine engine was used as the test bearing in an investigation of the effects of oil viscosity, oil flow, and oil inlet temperature on the operating characteristics of high-speed roller bearings.

FASTENINGS

How New Fuel Tank Sealer Works. George L. Christian. *Aviation Week*, Vol. 56, No. 12, March 24, 1952, pp. 61, 62, illus.

Development and advantages of the Chan-O-Seal method by Rohr Aircraft Corp. for hermetic sealing of aircraft fuel tanks and other aircraft structures which provides a continuous network of sealant for skin joints by incorporating a channel on one of the two butting metal surfaces and of a related method, the Lock-O-Seal, for bolts and rivets.

GEARS & CAMS

Gear-Tooth Stresses and Rating Formulae. I, II. H. E. Merritt. *The Engineer*, Vol. 193, Nos. 5015, 5016, March 7, 14, 1952, pp. 341–343; 384–387, illus.

An examination of current knowledge about the determination of permissible loading of gear teeth for various types of gears and of the consistency of and empirical factors entering into methods for determining the load; design applications.

Reaction Forces on Bevel Gear Drives. Paul F. Horbatt. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 199, 201, 203, illus. Charts for determining the magnitude and direction of the reaction components that act axially and radially on gear teeth.

Simplified Standards for Gears. W. A. Tuplin. *The Engineer*, Vol. 193, No. 5017, March 21, 1952, pp. 394–397, illus.

Materials (8)

CERAMICS & CERAMALS

Ceramic Coatings. *Aircraft Production*, Vol. 14, No. 161, March, 1952, pp. 107, 108, illus. Composition, method of application, and uses of A-417 ceramic coating.

Letters to the Editor: Discussion on "Resistance to Thermal Shock" by C. M. Cheng. E. Mayer. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, p. 98. 3 references. Thermal shock failure in ceramic materials.

CORROSION & PROTECTIVE COATINGS

A Critical Look at Salt Spray Tests. F. L. LaQue. *Materials & Methods*, Vol. 35, No. 2, February, 1952, pp. 77–81, illus. 11 references. Disadvantages and inaccuracies of the use of salt spray tests to measure the resistance of materials and finishes to corrosive environment.

Corrosion of Aluminum. George W. Orton. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data*

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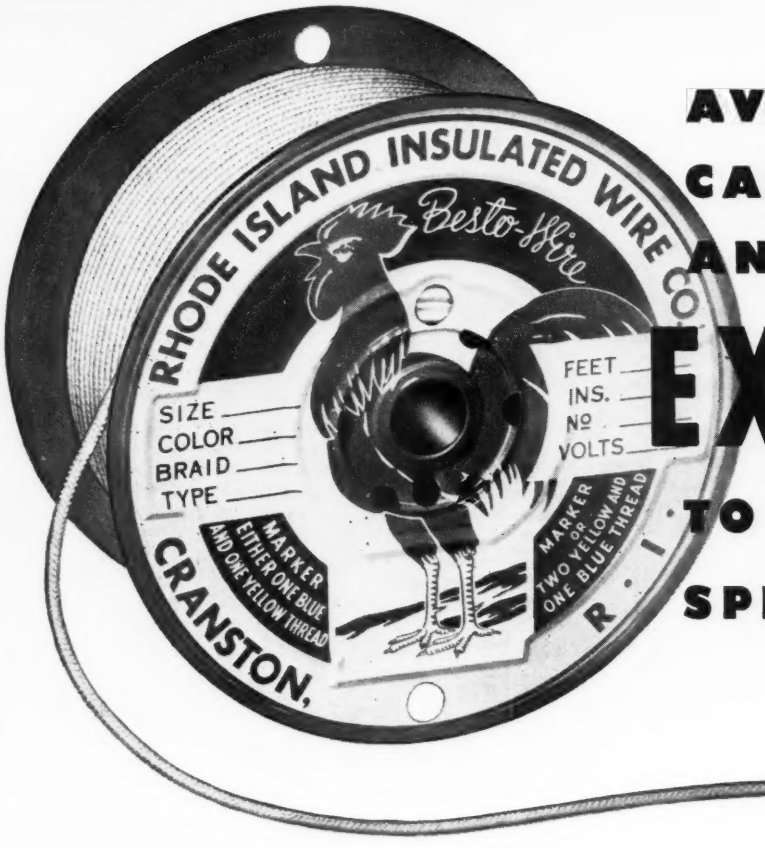

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Digest, Vol. 17, No. 3, March, 1952, pp. 16–23, illus. 36 references. Engineering principles involved in the corrosion of aluminum; methods for preventing corrosion.

New Protective Treatment for Aluminum Simplifies Processing at Reduced Costs. R. Stricklen. *Materials & Methods*, Vol. 35, No. 2, February, 1952, pp. 91–95, illus.

Properties, corrosion resistance, and methods of application of No. 14 (Al-Coat) to aluminum parts and to aluminum in contact with cathodic metals. A nonporous and amorphous chromate film is generated by a reaction that occurs when the Al part is immersed in the Iridite solution; the film, of a thickness of about 0.0001 in., becomes an integral part of the metal.

Corrosion of Magnesium Alloy ZK60A in Marine Atmosphere and Tidewater. Fred M. Reinhart. *U.S., N.A.C.A., Technical Note No. 2632*, February, 1952. 10 pp., illus.

Selecting Hard Facing Materials to Resist Impact, Heat, Friction, and Abrasion. Howard S. Avery. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 154–159, illus.

METALS & ALLOYS

Stratospheric Flight and Metallurgy. P. L. Teed. *The Aeroplane*, Vol. 82, No. 2122, March 21, 1952, pp. 334, 335, illus. Chemical, physical, and mechanical properties of aircraft metals under the conditions of temperature changes and wind-speed variations at high altitudes.

Creep Under Complex Stress Systems at Elevated Temperatures. A. E. Johnson. *Institution of Mechanical Engineers, Proceedings*, Vol. 164, No. 4, 1951, pp. 432–446, illus. 13 references.

Comparison, based on test data, of the complex stress creep characteristics of a cast 0.17 per cent carbon steel alloy tested at 350°, 450°, and 550° C., RR.59 Al alloy tested at 150° and 200° C., Mg alloy containing 2 per cent Al tested at 20° and 50° C., and Nimonic 75 Ni-Cr alloy tested at 550° and 650° C.

Fatigue Strengths of Aircraft Materials; Axial-Load Fatigue Tests on Notched Sheet Specimens of 24S-T3 and 75S-T6 Aluminum Alloys and of SAE 4130 Steel With Stress-Concentration Factor 1.5. H. J. Grover, W. S. Hyler, and L. R. Jackson. *U.S., N.A.C.A., Technical Note No. 2639*, February, 1952. 22 pp., illus. 3 references.

Thermal Shock Tests on Gas Turbine Materials. M. Bentele and C. S. Lowthian. *Aircraft Engineering*, Vol. 24, No. 276, February, 1952, pp. 32–38, illus. 12 references. A Study of the effects of severe temperature fluctuations on rotor blades and nozzle sections.

Trends in Gas Turbine Engine Materials. R. H. Thielemann, J. C. Mertz, and W. P. Eddy, Jr. *SAE Journal*, Vol. 60, No. 4, April, 1952, pp. 58–63, illus. (Excerpts from a paper.)

On the Empirical Law of Adhesive Wear. J. T. Burwell and C. D. Strang. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 18–28, illus. 17 references.

Measurements of the wear of rubbing steel surfaces as a function of load, distance of travel, and hardness under conditions that eliminated the effect of all factors except adhesion; investigation of the laws of galling wear. The results obtained on the dependence of wear rate on normal stress are used to explain the characteristics of the running-in processes.

Survey of Portions of the Cobalt-Chromium-Iron-Nickel Quarternary System. E. L. Kamen and Paul A. Beck. *U.S., N.A.C.A., Technical Note No. 2603*, February, 1952. 62 pp., illus. 14 references.

Boron Steel Development. D. L. McBride. *SAE Journal*, Vol. 60, No. 3, March, 1952, pp. 26–34, illus. 11 references. (Excerpts from a report.)

An Investigation of Boron and Other Low-Alloy Steels. II. H. B. Knowlton. *Steel Processing*, Vol. 38, No. 3, March, 1952, pp. 131–133, illus.

Materials Engineering File Facts No. 222: Boron Treated Types of Alternate Steels. *Materials & Methods*, Vol. 35, No. 2, February, 1952, pp. 127, 129.

Plating High-Tensile Steels. H. Cann and V. F. Henley. *Aircraft Production*, Vol. 14, No. 161, March, 1952, pp. 87, 88. Methods of producing electrodeposits on steels having an ultimate tensile strength exceeding 65 tons per sq.in.

Carbon Steels Successfully Welded by Inert-Gas-Shielded Metal Arc Process. H. T. Herbst and T. McElrath, Jr. *Materials & Methods*, Vol. 35, No. 2, February, 1952, pp. 86, 87, illus.

Creep in Metals. A. D. Schwope, F. R. Shober, and L. R. Jackson. *U.S., N.A.C.A., Technical Note No. 2618*, February, 1952. 52 pp., illus. 25 references. Apparatus, test procedure, and results of a study of creep in single crystals of high-purity aluminum.

Survey of the Chromium-Cobalt-Nickel Phase Diagram at 1200° C. W. D. Manly and Paul A. Beck. *U.S., N.A.C.A., Technical Note No. 2602*, February, 1952. 45 pp., illus. 6 references.

Temperature/Resistance Chart for Electrical Copper. A. E. Maine. *Electronic Engineering*, Vol. 24, No. 289, March, 1952, p. 111, illus.

Forming Titanium. *Aircraft Production*, Vol. 14, No. 161, March, 1952, pp. 74, 75, illus. Ryan Aeronautical Co.'s experimental work on aircraft-engine exhaust-systems.

Metallurgy of Titanium. H. D. Kessler and M. Hansen. *The Frontier*, Vol. 15, No. 1, March, 1952, pp. 4–7, 16–18, illus.

NONMETALLIC MATERIALS

Doped Fabric. Simon Williams. *Aero Digest*, Vol. 64, No. 2, February, 1952, pp. 100–107, illus. Development of an analytic procedure for predicting the failure of coated fabric surfaces.

Better Ways of Evaluating Properties of Plastics. Rolf Buchdahl and L. F. Nielsen. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 130–134, illus. 7 references. Instruments and methods for testing and evaluating the mechanical properties of plastics in terms of their physical characteristics.

CR-39 vs. Methyl Methacrylate at Elevated Temperatures in Double Glazed Units. O. D. Englehart. *Pittsburgh Plate Glass Co., Report No. 1263*, April 6, 1943. 8 pp., illus.

Materials & Methods Manual No. 79: Plastics As Alternate Materials. T. C. Du Mond. *Materials & Methods*, Vol. 35, No. 2, February, 1952, pp. 101–124, illus. Properties, types, classes, and applications of plastics; substitution of plastics for scarce metals.

Silicone Rubber for High-Speed Flight. Burton B. White. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 34, 36, 38, 42, 44, 47, illus.

Meteorology (30)

A Vertical Shaft for the Production of Thick Artificial Clouds and for the Study of Precipitation Mechanics. Ross Gunn. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 1–5, illus. 3 references.

Equipment and operation of a laboratory for the production of artificial clouds and for the study of the precipitation mechanism that was constructed in a vertical mine shaft by the U.S. Weather Bureau; preliminary data on droplet size distribution.

Ice Accretion on Aircraft. *Gt. Brit., Meteorological Office, Meteorological Reports No. 9* (Vol. II, No. 4), 1951. 36 pp., illus. 11 references. British Information Services, New York. $0.50.

An analysis of the properties of air and water in relation to the types and amount of ice that form during the icing of airframes and engines; meteorological situations in which icing occurs.

Atmospheric Oscillations and the Temperature Profile of the Upper Atmosphere. Luigi G. Jacchia and Zdeněk Kopal. *Journal of Meteorology*, Vol. 9, No. 1, February, 1952, pp. 13–23, illus. 17 references.

Cu-Nim Quest. *Flight*, Vol. 61, No. 2252, March 21, 1952, pp. 312, 313, illus. Methods of cumulus-nimbus penetration and data obtained by the R.A.F. No. 1301 Meteorological Flight unit on the intertropical front.

A High Speed Chronograph and Its Application to the Time of Flight of Cosmic Rays. V. C. Officer. *Australian Journal of Physics, Series A, Physical Sciences*, Vol. 4, No. 4, December, 1951, pp. 526–543, illus. 5 references.

Galactic Radiation at Radio Frequencies. IV—The Distribution of Radio Stars in the Galaxy. J. B. Bolton and K. C. Westfold. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 4, No. 4, December, 1951, pp. 476–488, illus. 20 references.

Observations of Galactic Radiation at Frequencies of 1210 and 3000 Mc/s. J. H. Piddington and H. C. Minnett. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 4, No. 4, December, 1951, pp. 459–475, illus. 27 references.

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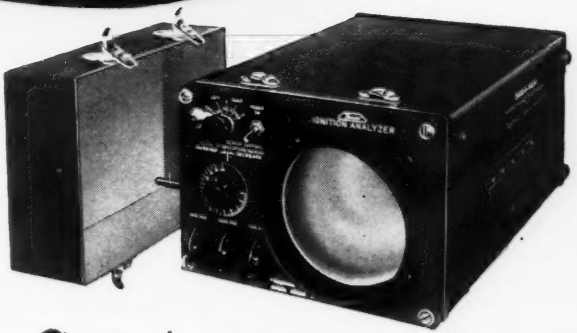

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The Position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s. I—Equipment. II—Noise Storms. A. G. Little and Ruby Payne-Scott. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 4, No. 4, December, 1951, pp. 489–525, illus. 38 references.

Letters to the Editor: Energy from the High Atmosphere. N. C. Gerson. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 98, 99. 2 references. Examples of the extraction of energy from the atmosphere above 80 km.; utilization of this energy by a rocket.

Military Aviation (24)

Low Level Flight and Low Level Attack. (*Flugwehr und Technik*, No. 12, 1946, pp. 307–311.) *Cornell Aeronautical Laboratory, Inc., Translation*, January, 1952. 10 pp.

Analysis of German war experiences using low-level flight and attack; disadvantages of low-level attack as a tactical maneuver; low-level attack tactics of the Allies and an evaluation of the results.

The Jet Bomber Confounds the Air Strategists. P. M. Gallois. *Interavia*, Vol. 7, No. 3, March, 1952, pp. 127–131, illus. Investigation of the problems of bomber strategy; tactical advantages of the light bomber; superiority of the jet bomber over the jet fighter.

Missiles (1)

The Effect of Nonlinear Aerodynamic Characteristics on the Dynamic Response to a Sudden Change in Angle of Attack. Telford W. Oswald. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 302–316, illus. 6 references.

Analysis of the effect of nonlinear variation of lift and pitching moment with angle of attack on the dynamic response to a step function input in angle of attack, assuming a missile flight path of constant speed and altitude.

Circuit Stability in Guided Missiles. R. L. Kelly. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 133–135, illus. Proper design of circuits and components results in maximum reliability of the systems.

Celestial Guidance for Missiles. James G. Strong. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 20–25, illus.

Principles of celestial star-tracking guidance systems for missiles; tracking mechanism; advantages of back-tracking and solar-tracking; landing the missile on the target.

Simultaneous A-M and F-M in Rocket Telemetering. W. Cullen Moore. *Electronics*, Vol. 25, No. 3, March, 1952, pp. 102–105, illus. 9 references.

Navigation (29)

Celestial Guidance for Missiles. James G. Strong. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 20–25, illus. Basic principles of star navigation; application as a guidance system for missiles.

Parachutes

WADC Develops Lightweight, Automatic-Opening Parachute. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 17, No. 3, March, 1952, p. 12, illus.

Automatic-opening personnel parachute weighs 22 lbs. and is 28 ft. in diameter; twelve conical-shaped guide surfaces that extend down from the canopy reduce oscillation and lower the opening shock.

Photography (26)

Photographic Techniques Applied to Combustion Studies—Two-Dimensional Transparent Thrust Chamber. John H. Altseimer. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 86–91, 103, illus. 1 reference.

Photographic equipment and techniques for rocket motor combustion chamber studies, using a transparent thrust chamber. Motion pictures were taken of the combustion process at 2,000 and 3,000 frames per sec., using an Eastman Type III, 16-mm. motion picture camera.

Power Plants

JET & TURBINE (5)

Application of Linear Analysis to an Experimental Investigation of a Turbojet Engine with Proportional Speed Control. Marcel Dandois and David Novik. *U.S., N.A.C.A., Technical Note No. 2642*, February, 1952. 38 pp., illus. 8 references.

Comparison of data from analytical and sea-level investigations of a turbojet engine with proportional speed control to evaluate the adequacy of linear analysis and synthesis techniques for predicting the stability and response of the controlled engine.

Design of Turbojet Engine Controls. J. F. Engelberger. *Aero Digest*, Vol. 64, No. 1, January, 1952, pp. 60–62, 64–68, illus. Complexity of turbojet engine control systems; design techniques; problems in obtaining fast response of control devices.

Investigation of Frequency-Response Characteristics of Engine Speed for a Typical Turbine-Propeller Engine. Burt L. Taylor, III, and Frank L. Oppenheimer. (*U.S., N.A.C.A., Technical Note No. 2184*, 1950.) *U.S., N.A.C.A., Report No. 1017*, 1951. 11 pp., illus. 2 references. Superintendent of Documents, Washington. $0.20.

Flying in Step. *Flight*, Vol. 61, No. 2252, March 21, 1952, pp. 328, 329, illus. Components, design, and operation of the automatic system developed by Rotol, Ltd. for synchronizing the speed of the power plants of multiengined turbojet aircraft.

The Turbo Compound Engine for Over-Ocean and Trunkline Transports. *Curtiss-Wright Corp., Wright Aeronautical Division*, December, 1951. 14 pp., illus. Specifications and operating details of the Wright 18-cylinder, 3-turbine, 3,250-hp. Turbo Compound engine.

French Nene Afterburner. Paul H. Wilkinson. *Aviation Age*, Vol. 17, No. 3, March, 1952, pp. 34, 35, illus.

Development, design, and operation of the afterburner for the Hispano-Suiza Nene turbojet engine that will be used in a new series of French Air Force interceptors. The afterburner raises the static thrust to 6,500 lbs. at take-off.

Afterburner. Robert McLarren. *Aero Digest*, Vol. 64, No. 2, February, 1952, pp. 60, 62–66, 68, 70, 72, 74, 76, illus. 8 references. Problems in afterburner design; performance characteristics; typical installations.

Jet Ignition Systems. L. J. Elliot. *Aero Digest*, Vol. 64, No. 2, February, 1952, pp. 28–32, 34, 36, 38, 42, 46, 48, 50, illus.

Outline of the development of ignition system for jet engines by the Scintilla Magneto Division of Bendix Aviation Corp.; characteristics and performance of the systems.

Thrust Augmentation. I. S. G. Allerton. *Society of Licensed Aircraft Engineers, Journal*, Vol. 1, No. 1, January, 1952 (*Technical Instructor*, Vol. 7, No. 1), pp. 15, 10, illus. Thrust augmentation on jet engines through the use of a ducted fan.

Performance of Axial Flow Turbines. D. G. Ainley. *Gt. Brit., National Gas Turbine Establishment, Report No. R. 38*, September, 1948. 53 pp., illus., folding charts. 6 references.

Survey of the development of the aerodynamic design of gas turbines from steam turbines and of some recent experimental data on turbine performance; effects of high Mach Number and a low Reynolds Number on the overall characteristics of high and low reaction turbines. A technique is presented for adequate full-scale testing of turbines.

RECIPROCATING (6)

National Puts Automatic Spark Advance to Use. N. Richard Sawyer. *Aviation Age*, Vol. 17, No. 3, March, 1952, p. 36, illus.

Results of flight tests by National Airlines of the Pratt & Whitney Automatic Spark Advance System on its DC-4, R-2002SD-13G engines; schematic diagram and operation of the system.

ROCKET (4)

Combustion Studies with a Rocket Motor Having a Full Length Observation Window. Kurt Berman and Stanley E. Logan. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 78–85, 103, illus. 1 reference.

Photographic investigation and results of combustion studies in a 3-in. diameter chamber, 1,200-lb. thrust rocket motor with a $^1/_4$- by $8^{21}/_{32}$-in. window, using a 35-mm. General Radio continuous camera and a Fastax high-speed movie camera. Results

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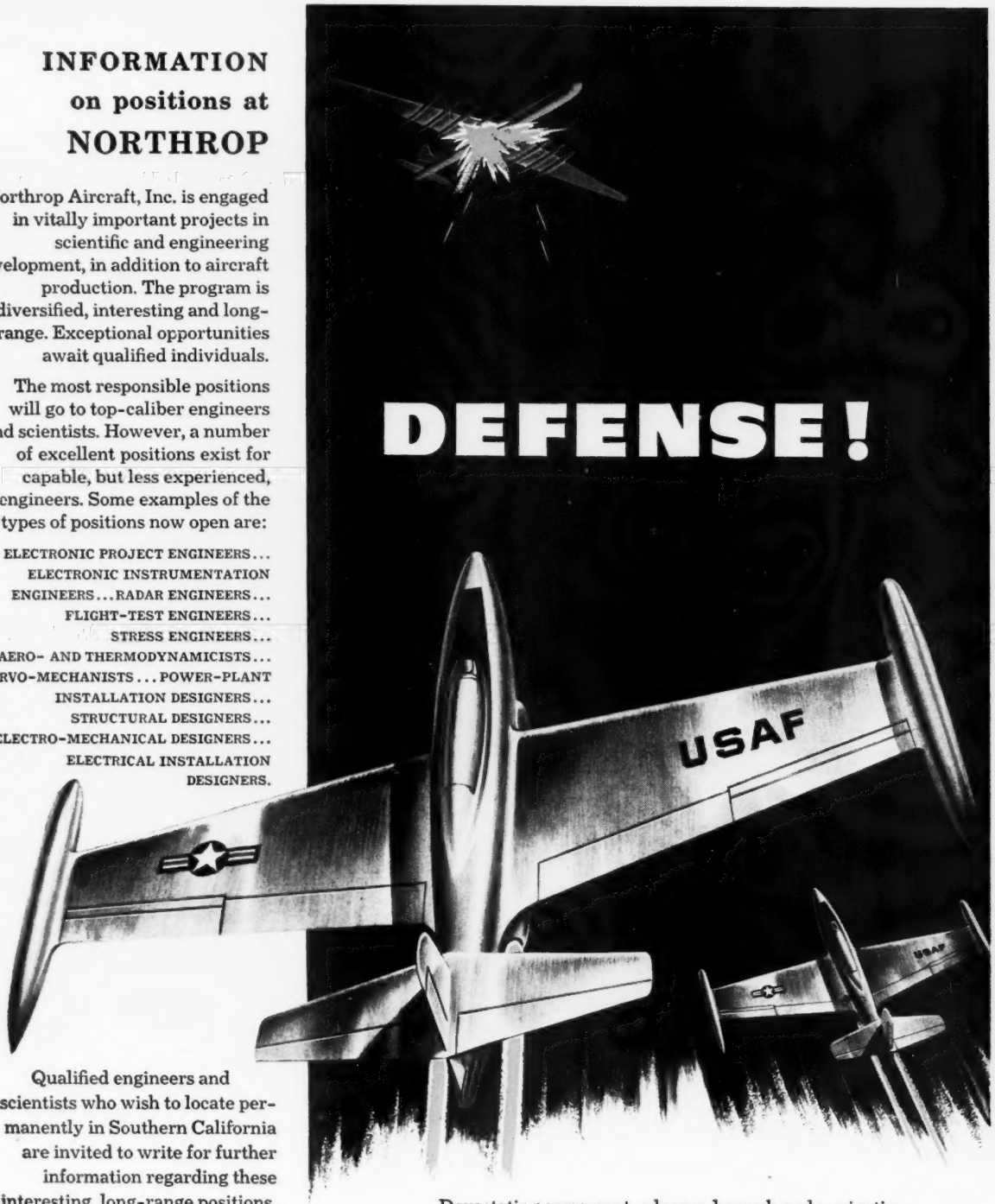

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Photographic Techniques Applied to Combustion Studies—Two-Dimensional Transparent Thrust Chamber. John H. Altseimer. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 86–91, 103, illus. 1 reference.

Results of photographic studies of the combustion process in a transparent thrust chamber. Five different injector types were studied, using a liquid bipropellant system.

Steady-State One-Dimensional Flow in Rocket Motors. E. W. Price. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 142–146, illus. 5 references.

A combined numerical and graphic method of analyzing flow problems in solid propellant rocket motors. Solutions are presented for the case of JPN ballistite propellant which give the equilibrium distributions of pressure, density, velocity, and temperature of the gas stream and burning rate of the solid propellant as functions of parameters of propellant charge and flow-channel geometry.

Liquid Propellant Rockets and Their Applications. J. Humphries. *Machinery Lloyd*, Overseas Edition, Vol. 23, No. 24, November 24, 1951, pp. 68–71, 73, 75, 77, 79, illus. A review of the method of operation of liquid propellant rocket motors; design problems; applications.

Propulsion by Rocket. S. Allen. *Canadian Aviation*, Vol. 25, No. 3, March, 1952, pp. 27, 55, 56, 58, 60, 62, illus. Design, operation, and evaluation of the Armstrong-Siddeley Snarler liquid-fuel rocket motor; its use on the Hawker P. 1072; rocket fuel system.

Production (36)

Elements of the Industry. *Aircraft*, Vol. 14, No. 3, March, 1952, pp. 26–28, 30, 32, 34, 36, 37, 41, 42, 44, 66, 67, 69, illus. Facilities and equipment of Canadian aircraft and engine companies; projects in development and production stages.

A Report on Canada's Aircraft Industry. *Aircraft*, Vol. 14, No. 3, March, 1952, pp. 18–20, 22, 24, 70, 71, illus.

Capacity and Location of Soviet Aircraft Plants. *Aviation Age*, Vol. 17, No. 3, March, 1952, pp. 6–17, illus.

Comparison of Soviet aircraft production requirements for raw materials, tools, and manpower with the resources actually available. A map shows the location of air frame and jet- and piston-engine manufacturing plants.

Redux in the (de Havilland) Comet. *Aero Research Technical Notes, Bulletin No. 110*, February, 1952. 8 pp., illus. Construction techniques using the Redux metal-to-metal bonding process.

Forging Blades for Avro Orenda Precise Operation. *Canadian Aviation*, Vol. 25, No. 3, March, 1952, pp. 28, 29, 50, 53, 55, illus.

Stretch-Forming. I—Construction and Operation of the Sheridan Longitudinal Machine; Forming Technique. *Aircraft Production*, Vol. 14, No. 161, March, 1952, pp. 77–84, illus., cutaway drawings.

Specialty Die Designs for Stamping and Forming. I—The Marform Process. Lester F. Spencer. *Steel Processing*, Vol. 38, No. 3, March, 1952, pp. 121–127, illus. 5 references.

Theory of Electric Spark Machining. E. M. Williams. *Electrical Engineering*, Vol. 71, No. 3, March, 1952, pp. 257–260, illus. 13 references. Theory, circuit, construction, and operation of electric-spark cutting equipment for machining hard metals; comparison of theory with experiment.

Blade Construction Processes. O. L. L. Fitzwilliams. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 358–361, illus. Design, facilities, and method of machining and producing the metal rotor blades for the Westland-Sikorsky S.51 and S.55 helicopters.

Blade-Profiling; Pratt and Whitney Eight-Spindle Duplicating Machine. *Aircraft Production*, Vol. 14, No. 161, March, 1952, p. 76, illus.

New Horizons for Aero Machinery. Malcolm F. Judkins. *SAE Journal*, Vol. 60, No. 4, April, 1952, pp. 49, 52, illus. Report of the S.A.E. Aircraft Production Panel on Machinery.

Spotwelding Highly Stressed Aluminum and Magnesium Assemblies. A. Schoellerman and S. Jenkins. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 185–188, illus.

Fir-Tree Form Inspection. *Aircraft Production*, Vol. 14, No. 161, March, 1952, pp. 89–95, illus.

Development of a high-speed semiautomatic multidimensional inspection unit by the Sigma Instrument Co. Ltd., for checking the fir-tree root-form of gas-turbine blades. The unit incorporates a number of linear-scale gaging heads and can simultaneously inspect 13 points of the blade-root.

Building the Brabazon; Some Production Problems Encountered in the Manufacture of a Very Large Prototype. F. J. Chard. *Aircraft Production*, Vol. 14, No. 161, March, 1952, pp. 100–106, illus.

Building World's Biggest Bombers. *Automotive Industries*, Vol. 106, No. 7, April, 1952, pp. 38–41, 82, illus. Equipment, facilities, and production methods for the B-36 at Convair's Fort Worth plant.

Convair 340 on the Line. *Aviation Week*, Vol. 56, No. 12, March 24, 1952, pp. 52, 53, illus. Production and assembly techniques.

Propellers (11)

Readers' Forum: Extension of "The Dynamic Effects in Rotor Blade Bending" by A. H. Flax and L. Goland. Robert A. Rogers. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, pp. 349, 350, illus. Extension to the case of a rotating propeller where the blades may be near resonance.

Reference Works (47)

Aviation Business Directory of Greater New York. Vol. 4, No. 1, Winter, 1952. 50 pp., illus. An alphabetically arranged directory of the names, addresses, and telephone numbers of aviation firms, services, and government offices in the greater New York area.

British Military Aircraft. *The Aeroplane*, Vol. 82, No. 2123, March 28, 1952, pp. 358–382, illus.

Photographs and specifications of R.A.F. and R.N. aircraft; R.A.F. squadron insignia; list of nations that use, or build under license, British military aircraft types.

The British Independent Operators. *The Aeroplane*, Vol. 82, No. 2121, March 14, 1952, pp. 305–309, illus.

A directory that gives a short summary of the history and development of each of the independently operated British airlines and includes their names, registered addresses, main bases, aircraft types and number, numbers of staff and pilots, and miles flown in 1951.

13th Annual Directory. *Aero Digest*, Vol. 64, No. 3, March, 1952. 160 pp., illus.

Specifications, performance, and photographs of U.S. military, transport, and personal aircraft; helicopters, reciprocating and jet power plants; and propellers. Alphabetical lists of company addresses and key personnel of air-frame, power-plant, and accessories manufacturers. Directory of manufacturers of airborne accessories classified alphabetically under product listings.

Annual Air Transport Issue. *American Aviation*, Vol. 15, No. 44, April 28, 1952. 150 pp., illus.

Review of U.S. air transport economics, operations, maintenance, equipment, and air traffic; international air transport statistics; transport aircraft of the world; directory of the world's air lines which lists the corporate name, address, equipment, number of employees, and number of pilots of each air line. The 13th Air Transport Facts and Figures, compiled by the Air Transport Association of America, is included.

34th Annual Statistical Issue. *Automotive Industries*, Vol. 106, No. 6, March 15, 1952. 576 pp., illus. Includes aviation data: aircraft and engine production, shipments, civil aircraft registrations and shipments; airport registrations.

Rotating Wing Aircraft (34)

Whirling Wings. I, II. Ronald A. Keith. *Canadian Aviation*, Vol. 25, Nos. 3, 4, March, April, 1952, pp. 22–26, 70; 52, 54, 62, 65, illus. Review of the U.S., British, and Canadian helicopter industry.

Military Aspects of the Transport Helicopter. F. N. Piasecki. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 311–325, Discussion, pp. 326–329, illus. 28 references. Abridged version of a paper.

Hiller 360 Agricultural Helicopter. *Esso Air World*, Vol. 4, No. 4, January-February, 1952, pp. 106, 107, illus.

Airworthiness in the Presence of Vibrations. R. H. Warde. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1,

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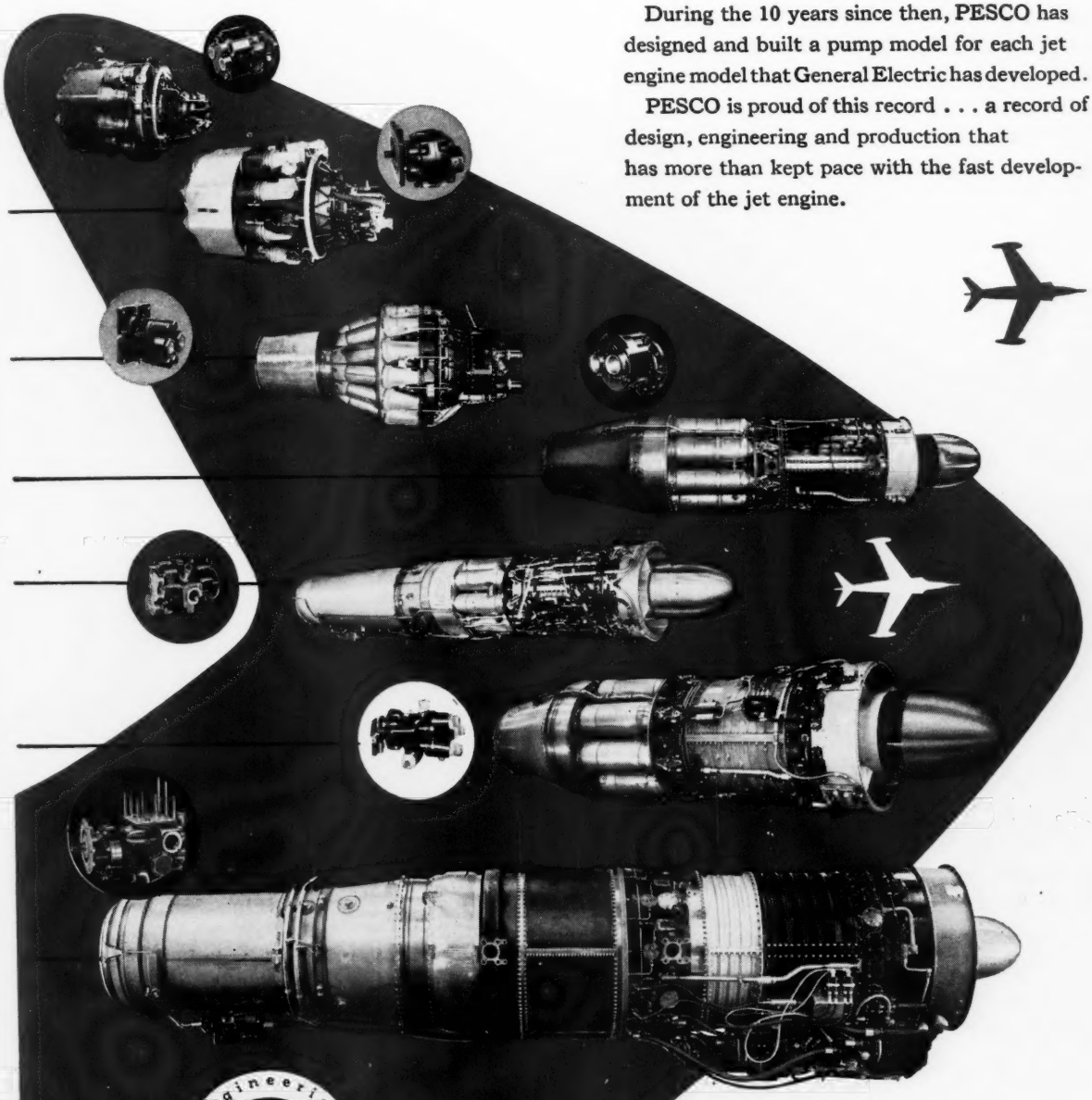

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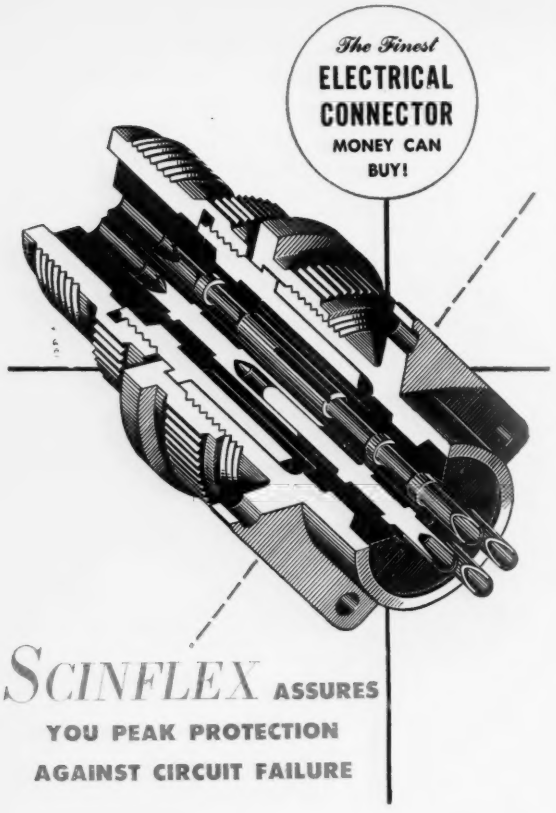

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April–June, 1951, pp. 209–212, Discussion, pp. 218–225. Test procedure for prototype helicopters under conditions of vibration; methods of maintaining helicopter airworthiness.

The Fatigue Problem with Emphasis on the Airworthiness Aspect. J. K. Williams. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1, April–June, 1951, pp. 213–218, Discussion, pp. 218–225.

A Brief Survey of Characteristic Vibration Sources in Helicopters. J. Shapiro. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 4, January–March, 1951, pp. 192–196, Discussion, pp. 196–201.

Some Operational Aspects of Helicopter Vibration. A. McClements. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 4, January–March, 1951, pp. 183–191, Discussion, pp. 196–201, illus. 8 references. Problems and sources of noise and mechanical vibration in helicopters.

Some Present and Future Aspects of Helicopter Piloting. J. S. Fay. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 4, January–March, 1951, pp. 137–171, Discussion, pp. 171–182, illus. 6 references.

The Pressure-Jet Helicopter—Performance Data and Operating Experience. Igor B. Bensen. *Aeronautical Engineering Review*, Vol. 11, No. 6, June, 1952, pp. 41–51, illus. 7 references.

Results of a detailed evaluation study of a captured German helicopter that utilized the Doblhoff pressure-jet propulsion system; specifications and performance data; thermodynamics of the propulsion system.

Some Aerodynamic Aspects of Rotor Blade Design. H. B. Squire. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 331–339, Discussion, pp. 351–353, illus. 14 references. A survey of the effects of taper and twist, stalling, compressibility, and the thickness, section, and surface condition of the airfoil on rotor-blade design.

Tuning the Rotor. K. W. Turner. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 362–369, illus. Methods of measuring and adjusting r.p.m., vibration, and stability of a three-blade rotor under operating conditions.

An Investigation of Bending-Moment Distribution on a Model Helicopter Rotor Blade and a Comparison with Theory. John R. Meyer, Jr. *U.S., N.A.C.A., Technical Note No. 2626*, February, 1952. 91 pp., illus. 5 references.

General Principles of the Structural Design of Helicopter Blades. J. B. B. Owen. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 340–351, Discussion, pp. 351–353, illus.

Blade Construction Processes. O. L. L. Fitzwilliams. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 358–361, illus. Design, facilities, and method of machining and production of the metal rotor blades for the Westland-Sikorsky S.51 and S.55 helicopters.

The Construction of Resin-Bonded Composite Type Rotor Blades, etc. E. P. King. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 373–381, illus. 7 references. Structural and aerodynamic advantages of resin-bonded composite metal-wood or metal-fiber helicopter blades; design and assembly processes.

Jet-Propelled Rotor-Blade Construction. F. L. Hodgess. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 354–357, illus. 2 references.

The Manufacture of Wooden Helicopter Blades. N. B. Morris. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 3, October–December, 1951, pp. 370–372, illus.

Readers' Forum: Attachment of Rotor Blades by Laminated Elastic Straps. Kurt H. Hohenemser. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, p. 350. 4 references. Development of a criterion for avoiding chordwise self-excited mechanical oscillations of rotor blades in designing the strap attachment.

A Simplified Analysis of Helicopter and Automatic Pilot Dynamic Stability. I. John E. Burkam. *American Helicopter*, Vol. 25, No. 3, February, 1952, pp. 8–10, 14, illus.

NACA Probes into Tandem-Rotor Control. David A. Anderton. *Aviation Week*, Vol. 56, No. 11, March 17, 1952, pp. 19, 20, 23, illus.

Test instruments and data on the Piasecki HRP-1 twin-rotor helicopter that has a metal strip around the forward fuselage which acts as a spoiler and makes the flow turbulent along the fuselage and increases the static stability in yaw.

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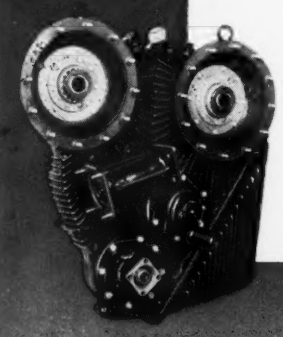

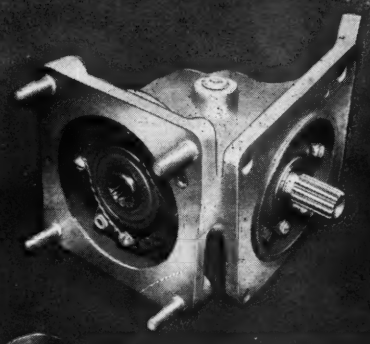

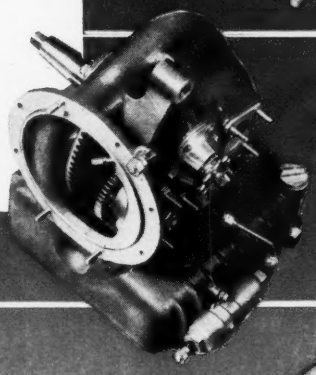

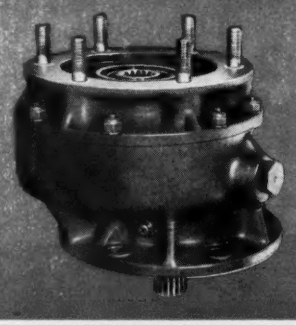

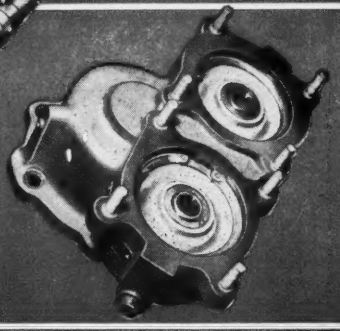

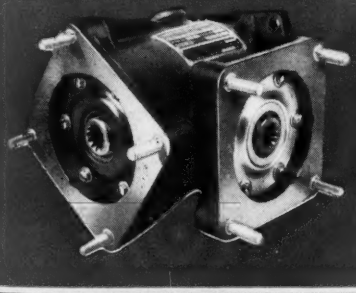

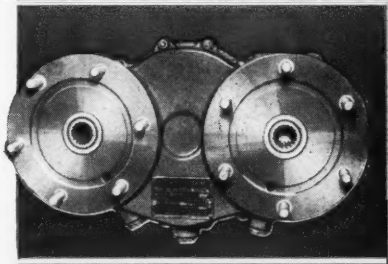

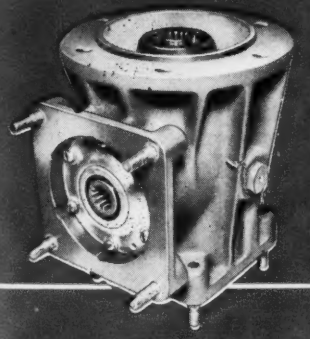

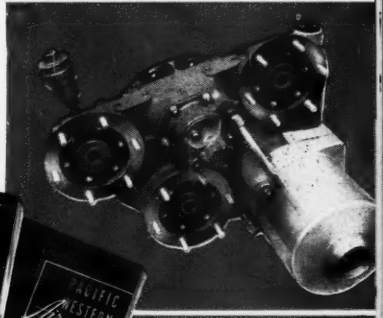

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The Measurement of Vibration. G. E. Bennett. *Helicopter Association of Great Britain, Journal*, Vol. 5, No. 1, April–June, 1951, pp. 206–209. Problems in the choice of instruments for measuring helicopter vibration in ground-resonance and flight tests.

General Handling Tests of the Sikorsky R-4B Helicopter (Hoverfly Mk. 1). W. Stewart. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2431*, 1951 (October, 1946). 21 pp., illus. British Information Services, New York. $1.25. Flight-test program and results to assess general handling characteristics of the Sikorsky R-4B helicopter.

Sciences, General (33)

MATHEMATICS

The Oscillating Wing in a Subsonic Flow. *Netherlands, Mathematisch Centrum, Amsterdam, Report No. R 53, Int. 1–8*, 1949–1951. 182 pp., illus., tables. 3 references.

Mathematical theory and computations; derivations of the Fourier expansions; development of the Fourier coefficients $B_m^{(n)}$ in factorial series; numerical values of $B_m^{(n)}$ and the characteristic values b_n of odd Mathieu functions $se_n(x)$; definitions of the integrals involved in these computations; expansion of $B_m^{(n)}$ and a_n into power series; numerical values for the real and imaginary parts of the functions.

A Note on Bounds of Multiple Characteristic Roots of a Matrix. P. Stein. *U.S., National Bureau of Standards, Journal of Research*, Vol. 48, No. 1, January, 1952, pp. 59, 60. 1 reference. (Also available as *Research Paper No. 2284*. Superintendent of Documents, Washington. $0.05.)

Solution of $Ax = \lambda Bx$. M. R. Hestenes and W. Karush. *U.S., National Bureau of Standards, Journal of Research*, Vol. 47, No. 6, December, 1951, pp. 471–478. 3 references. (Also available as *Research Paper No. 2275*. Superintendent of Documents, Washington. $0.10.) Calculations to determine characteristic numbers and vectors for the problem $Ax = \lambda Bx$, where A, B are $n \times n$ Hermitian matrices.

On Some Functionals of Laplacian Processes. R. Fortet. *U.S., National Bureau of Standards, Journal of Research*, Vol. 48, No. 1, January, 1952, pp. 32–39. 4 references. (Also available as *Research Paper No. 2280*. Superintendent of Documents, Washington. $0.10.)

Random Determinants. R. Fortet. *U.S., National Bureau of Standards, Journal of Research*, Vol. 47, No. 6, December, 1951, pp. 465–470. (Also available as *Research Paper No. 2274*. Superintendent of Documents, Washington. $0.10.)

Development of equations for determinants whose elements involve random variables; derivation of expressions for the first and second moment; application to n-dimensional geometry.

A New Method for the Evaluation of Zeros of Bessel Functions and of Other Solutions of Second-Order Differential Equations. F. W. J. Oliver. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 4, October, 1950, pp. 570–580. 5 references.

Theoretical and Experimental Averages of Turbulent Functions. J. Kampé de Fériet and R. Betchov. *K. Nederlandse Akademie van Wetenschappen, Proceedings, Series B*, Vol. 54, No. 4, 1951, pp. 389–398, illus. 13 references. Reprint.

The Use of the Null-Unit Function in Generalized Integration J. J. Smith and P. L. Alger. *Franklin Institute, Journal*, Vol. 253, No. 3, March, 1952, pp. 235–250. 7 references.

Note on a Generalization of Rayleigh's Principle. W. J. Duncan. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 93–96. 2 references.

MECHANICS

On Double-Pulse Stability Criteria with Damping. M. Morduchow and L. Galowin. *Quarterly of Applied Mathematics*, Vol. 10, No. 1, April, 1952, pp. 17–23, illus. 8 references.

Derivation of a simple necessary condition for the stability of a linear dynamic system with elastic and damping characteristics that vary periodically with the same period; development of general, explicit, necessary and sufficient conditions for the stability of double-pulse system; physical significance of the results.

PHYSICS

Coincidence Method Applied to Ion Beam Measurement. Stanley Fultz and M. L. Pool. *U.S., N.A.C.A., Technical Note No. 2627*, February, 1952. 13 pp., illus. 4 references. Development of coincidence Geiger counter system for the absolute measurement of the activity of radioactive substances made in a cyclotron.

Space Travel

Artificial Satellites—Key to Space Flight? L. N. Thompson. *Interavia*, Vol. 7, No. 3, March, 1952, pp. 148–150, illus. Examination of basic problems of space flight—escape velocity, landing procedures, atomic power plants, and suborbital satellite techniques.

Letters to the Editor: Energy from the High Atmosphere. N. C. Gerson. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, pp. 98, 99. 2 references. Examples of the extraction of energy from the atmospheres above 80 km.; utilization of this energy by a rocket.

Man Without Gravity; The Physiological and Psychological Problems of Space-Flight. L. N. Thompson. *Flight*, Vol. 61, No. 2251, March 14, 1952, pp. 298–300, illus. 8 references.

Structures (7)

On Cracks and Dislocations in Shafts Under Torsion. Alexander Weinstein. *Quarterly of Applied Mathematics*, Vol. 10, No. 1, April, 1952, pp. 77–81. 10 references.

Application of the theory of sources and sinks in a space of five dimensions to problems of cracks and dislocations in a shaft under torsion. A new and simple correspondence principle is used, connecting the method of sources and sinks with electrostatic problems in generalized axially symmetric potential theory.

Torsional Fatigue Failures. II. J. O. Almen. *Product Engineering*, Vol. 23, No. 3, March, 1952, pp. 168–174, illus. Data on the characteristics of torsional failures obtained from fatigue tests of torsion bars subjected to experimental variations in processing.

On the Combined Torsion and Tension of a Partly Plastic Circular Cylinder. F. A. Gaydon. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 29–41, illus. 2 references.

Analysis of combinations of twist and extension on a solid circular cylinder. Integration of the Reuss equations gives the shear stress and tension in the plastic material. The case of a bar that is twisted and extended in constant load-to-torque ratio is solved numerically, and the residual stresses are evaluated for the bar after partial unloading.

Stress Problems in Pressurized Cabins. W. Flügge. *U.S., N.A.C.A., Technical Note No. 2612*, February, 1952. 91 pp., illus. 11 references.

Theory and data for use in the design of pressurized aircraft cabins or similar lightweight pressure vessels. Shell and plate problems are considered, the former in connection with the curved walls of the cabin pressure vessel and the latter with small rectangular panels of its walls, framed by stiffeners, but not necessarily plane.

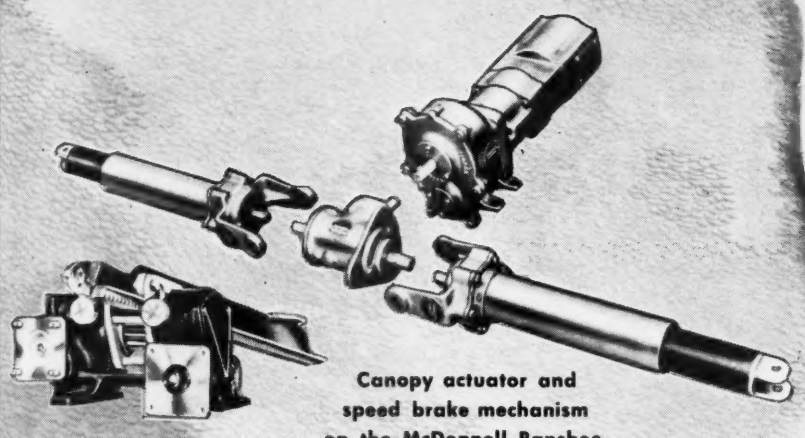
The Analysis of Fuselage Frames. I. William Morse. *Aircraft Engineering*, Vol. 24, No. 276, February, 1952, pp. 39–44, 49, illus. 3 references. Solution by the elastic center method of problems in the design of built-in frames and fuselage rings.

Principle and Application of Complementary Energy Method for Thin Homogeneous and Sandwich Plates and Shells with Finite Deflections. Chi-Teh Wang. *U.S., N.A.C.A., Technical Note No. 2620*, February, 1952. 33 pp., illus. 9 references.

The Distribution of Stress in the Neighbourhood of a Flat Elliptical Crack in an Elastic Solid. A. E. Green and I. N. Sneddon. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 1, January, 1950, pp. 159–163. 4 references.

Elastic Deformations of Infinite Strips. H. G. Hopkins. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 1, January, 1950, pp. 164–181, illus. 7 references.

A Critical Examination of the Representation of Massive and Elastic Bodies by Systems of Rigid Masses Elastically Connected. W. J. Duncan. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 97–108. 6 references.



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Two-Dimensional Plastic Stress Systems with Isometric Principal Stress Systems. P. F. Neményi and A. van Tuyl. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 1–11. 3 references.

The Bending of Thin Anisotropic Plates. Edith Illing. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 5, Part 1, March, 1952, pp. 12–28. 10 references.

Analysis, by the method of complex potentials, of the problem of a thin circular plate that is clamped around its edges and bent by a general force applied to one face.

Readers' Forum: Comments on "Uniformly Loaded Semi-Infinite Wedge-Shaped Plates" by A. J. A. Morgan. M. L. Williams. *Journal of the Aeronautical Sciences*, Vol. 19, No. 5, May, 1952, p. 354. 2 references.

Stresses and Deformations in Wings Subjected to Torsion. B. F. Ruffner and Eloise Hout. *U.S., N.A.C.A., Technical Note No. 2600*, February, 1952. 79 pp., illus. 18 references.

Development of an approximate solution of the von Kármán and Chien equations for restrained torsion of rectangular tubes of arbitrary cross section loaded with a couple; application to tubes of rectangular, elliptical, and airfoil cross section.

Elastic Instability of a Swept Panel. E. H. Mansfield. *Aircraft Engineering*, Vol. 24, No. 276, February, 1952, pp. 48, 49, illus. Analysis of the buckling tendency of a panel of the top skin of a swept wing.

Thermodynamics (18)

Use of Radiation from Incandescent Particles as an Indication of Flame Temperature. Earle K. Plyler and Curtis J. Humphreys. *U.S., National Bureau of Standards, Journal of Research*, Vol. 47, No. 6, December, 1951, pp. 456–460, illus. 5 references. (Also available as *Research Paper No. 2272*. Superintendent of Documents, Washington. $0.10.)

Equipment, procedure, and results of an experimental study of opaque and semiopaque flames to determine whether the radiation from incandescent carbon particles could be used for measuring flame temperature.

Flame Speeds of Methane-Air, Propane-Air, and Ethylene-Air Mixtures at Low Initial Temperatures. Gordon L. Dugger and Sheldon Heimel. *U.S., N.A.C.A., Technical Note No. 2624*, February, 1952. 25 pp., illus. 16 references.

An investigation of the effect of initial temperature on flame speed in which flame speeds were computed for initial temperatures of −73° and −132° C. for methane-air mixtures and −73° C. for propane-air and ethylene-air mixtures.

Letters to the Editor: Comments on "Boundary Conditions in the Theory of One-Dimensional Flame Propagation" by T. C. Adamson, Jr. Howard W. Emmons. *American Rocket Society, Journal*, Vol. 22, No. 2, March-April, 1952, p. 97.

Conduction of Heat in a Solid with a Power Law of Heat Transfer at Its Surface. J. C. Jaeger. *Cambridge Philosophical Society, Proceedings*, Vol. 46, Part 4, October, 1950, pp. 634–641, illus. 7 references.

Experimental and Theoretical Activities in the Gas Properties Field, 1948 to Date. Ivan F. Weeks. *Wisconsin, University, Naval Research Laboratory, Department of Chemistry, Report No. CM-703*, January 8, 1952. 47 pp. 259 references.

Water-Borne Aircraft (21)

5-A Finnmark All-Metal Twin-Engined Amphibian Flying Boat, Finland. *Aviation Age*, Vol. 17, No. 3, March, 1952, pp. 119, 120, illus. Design and performance data.

Future of the Flying-Boat. Henry Knowler. (5th Louis Blériot Lecture, Paris, March 12, 1952.) *The Aeroplane*, Vol. 82, No. 2121, March 14, 1952, pp. 295–297, illus. *Flight*, Vol. 61, No. 2251, March 14, 1952, pp. 293–297, illus.

Wind Tunnels & Research Facilities

The Climatic Hangar. Bailey C. Cook. *U.S., Air Force, Air Proving Ground*, 1952. 31 pp., illus. Climatic hangar, associated test facilities, and scope of work done at the U.S.A.F. Climatic Laboratories, Eglin A.F.B., Florida.

World's Worst Weather Helps Build World's Best Air Force. *Instrumentation*, Vol. 5, No. 6, 1st Quarter, 1952, pp. 4–7, 34, illus.

Scope of operations, instrumentation and refrigeration system of the Environmental Test Center facilities at the U.S.A.F.'s Wright Air Development Center; mechanisms for creating special climatic conditions.

Aeronautical Research in Canada. *Aircraft*, Vol. 14, No. 3, March, 1952, pp. 46,48, 50, 69, 70, illus. Organizations, facilities, personnel training, and methods of pure research in aeronautics in Canada.

Direct Measurements of Skin Friction. Satish Dhawan. *U.S., N.A.C.A., Technical Note No. 2567*, January, 1952. 60 pp., illus. 26 references.

Survey of possible methods of determining skin friction; design and construction of a device that directly obtains local skin friction data by measuring the shear force exerted upon a small movable part of a solid boundary by means of a reluctance pickup.

A Water Analogue of the Isentropic Flow of Compressible Gases Which Have Arbitrary Ratios of Specific Heats. Ronald F. Probstein and George E. Hudson. *U.S., Office of Naval Research, Project Squad, Technical Report No. 15*, August, 1948. 24 pp., illus. 3 references.

Mathematical development of the theory of obtaining a water analog of the gas flow for which the γ (the ratio of specific heats) is other than 2.0. A water channel, whose cross section was not rectangular, was used to obtain the sound-wave velocities of such flows.

The Supersaturation of Nitrogen in a Hypersonic Wind Tunnel. I. Faro, T. R. Small, and F. K. Hill. *Journal of Applied Physics*, Vol. 23, No. 1, January, 1952, pp. 40–43, illus. 10 references.

Procedure and results of tests made in a small hypersonic wind tunnel of the condensation of pure dry nitrogen at temperatures from 52°–64° R. and pressures from 0.5–2.8 mm. Hg at a nominal Mach Number of 9.0.

An Experimental Investigation of Gust Loads on an Airfoil at High Subsonic Airspeeds. Robert A. Holdahl. **Appendix.** B. M. Leadon. *Minnesota, University, Institute of Technology, Department of Aeronautical Engineering, Research Report No. 69*, November 1, 1950. 64 pp., illus. 6 references.

Development of a wind-tunnel test section (1.25- by 20-in.) with a balance system capable of rotating an NACA 64A012 airfoil with a 3.25-in. chord through a small angle of attack and of recording the force development with respect to time. Results are given of a series of tests conducted at a Mach Number of 0.5 and a Reynolds Number of 2.9×10^6.

Supersonic Wind Tunnel Data Recorded on "Production Basis." *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 17, No. 3, March, 1952, pp. 4, 5, illus.

A multiple channel manometer, in use at the Supersonic Wind Tunnel of the U.S. Naval Ordnance Laboratory at White Oak, Md., for measuring the pressure distributions on models of guided missiles at $M = 4.28$ and 5.18. The manometer, which has a bank of 72 tubes, has built-in automatic controls and apparatus to photograph the positions of the meniscuses. A film reader takes data directly from the photographic negatives.

Aeronautical Reviews — BOOKS

Book Notes

AIR TRANSPORTATION

Air Transport Facts and Figures. 13th Ed. Washington, D.C., Air Transport Association of America, 1952. 20 pp., illus., tables.

CRUISE CONTROL

Cruise Control for Low Powered Airplanes, Including Complete Cruising Charts for Cessna 195, 170A, and 14A Airplanes. Max Daggett, Jr. Little Rock, Arkansas, Air Service and Engineering, P.O. Box 2715. 1951. 7 pp., folding charts. $1.00.

ELECTRONICS

Symposium on the Integration of Electronic Equipment with Air-Frame Design. (I.R.E., National Convention, New York, March 6, 1952. Professional Group on Airborne Electronics, Transactions, PGAE-3.) New York, Institute of Radio Engineers, Inc., April, 1952. 28 pp., illus., figs. $2.50 (I.R.E. P.G.A.E. Members, $0.85; I.R.E. Members and Public Libraries and Colleges, $1.25).

Contents: The Integration of Electronic Equipment with Air Frame Design, C. W. Dix and A. F. Coombs. The Unique Airplane Environment Effect on Electronic Equipment, D. T. Geiser. Electronic Components for Airborne Requirements, F. E. Wenger.

Review of Electronic Digital Computers. Papers and Discussions Presented at the Joint A.I.E.E.-I.R.E. Conference, Philadelphia, December 10-12, 1951, with the Participation of the Association for Computing Machinery. New York, American Institute of Electrical Engineers, February, 1952. 114 pp., illus., diagrs., figs. $3.50.

Contents: Keynote Address, W. H. MacWilliams, Jr. The UNIVAC System, J. Presper Eckert, Jr., James R. Weiner, H. Frazer Welsh, and Herbert F. Mitchell. Performance of the Census UNIVAC System, J. L. McPherson and S. N. Alexander. The Burroughs Laboratory Computer, G. G. Hoberg. IBM Card-Programmed Calculator, J. W. Sheldon and Liston Tatum. The ORDVAC, R. E. Meagher and J. P. Nash. Design Features of the ERA 1101 Computer, F. C. Mullaney. The Operation and Logic of the MARK III Electronic Calculator in View of Operating Experience. Glen E. Porte. The University of Manchester Computing Machine, F. C. Williams and T. Kilburn. The Design, Construction, and Performance of a Large-Scale General-Purpose Digital Computer, B. W. Pollard. The Whirlwind I Computer, R. R. Everett. Evaluation of the Engineering Aspects of Whirlwind I, Norman H. Taylor. The EDSAC Computer, M. V. Wilkes. The National Bureau of Standards Eastern Automatic Computer (SEAC), S. N. Alexander. Engineering Experience with the SEAC, Ralph J. Slutz. Computing Machines in Aircraft Engineering, Charles R. Strang. A Review of the Bell Laboratories' Digital Computer Developments, E. G. Andrews. The Transistor as a Digital Computer Component, J. H. Felker. Digital Computers—Present and Future Trends, J. W. Forrester.

FUELS & LUBRICANTS

The Performance of Lubricating Oils. H. H. Zuidema. New York, Reinhold Publishing Corporation, 1952. 179 pp., illus., figs. $5.00.

This 113th volume in the American Chemical Society Monograph Series summarizes and evaluates available data on the performance characteristics of lubricating oils under various conditions. The subject is approached from the point of view of performance rather than specific application, such as aircraft oils and motor oils. Entire chapters are devoted to the lubrication process, flow characteristics, oxidation, bearing corrosion, sludge and lacquer deposition, emulsification and foaming, and wear. The final chapter, on manufacturing methods, points out the effects of each step in the manufacturing process upon the performance characteristics of the final product. Over 275 references are cited at the ends of chapters, and there are author and subject indexes. The author is associated with the Shell Oil Company's Research Laboratories at Wood River, Illinois.

HYDRAULICS

An Elementary Text in Hydraulics and Fluid Mechanics. Ralph W. Powell. New York, The Macmillan Company, 1951. 316 pp., illus., diagrs., figs. $4.75

The last edition of *Mechanics of Liquids*, of which this work is a revision, was published in 1940. In the present edition, some treatment of gases has been included, and new articles have been added such as those on fluid pressure mechanisms, and flow through porous material. More than half of the text has been revised to take into account developments in hydraulic research since 1939. The author is Professor of Mechanics, The Ohio State University.

MAINTENANCE

Civil Air Regulations and Reference Guide for A & E Mechanics. New Ed. Los Angeles, Aero Publishers, Inc., 1952. 120 pp., diagrs., figs. $2.00.

This volume lists Government requirements for securing and retaining aircraft and aircraft-engine mechanics' licenses and contains Parts 4a, 13, 14, 15, 18, 24, 52, and 60 of the Civil Air Regulations, numerous check questions, and sample copies of Government inspection forms.

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Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

MANAGEMENT & FINANCE

Key Role of Aircraft Industry and Selected Individual Company Analyses. Prepared by Selig Altschul. New York, Kidder, Peabody & Co., 1952. 44 pp.

An appraisal of the U.S. aircraft manufacturing industry in relation to national defense and of present and future production and earnings. Two-thirds of the booklet is devoted to statistical data and discussions summarizing the outlook, position in the industry, principal current products and contracts, facilities, finances, sales, and earnings of ten companies.

MATERIALS

The Non-Destructive Testing of Metals. R. F. Hanstock. (Monograph and Report Series, No. 10.) London, Institute of Metals, 1951. 163 pp., illus., diagrs., figs. 21*s*.

The main theme is the restatement of certain sections of the sciences, mainly classical physics, which have a particular bearing on the nondestructive examination of metals. After a brief introduction outlining a few types of test which are not treated at length in the text, the author takes up the measurement of thickness, the evaluation of surface finish, the detection of cracks at or near the surface, radiography, the detection of flaws by ultrasonic methods, and dynamic tests. Three chapters are devoted to damping capacity: Chapter 8, Definitions and Methods of Measurement; Chapter 9, Dependence on Metallurgical Condition; and Chapter 10, Theoretical Aspects. The remaining chapters are concerned with X-ray diffraction, electrical and magnetic methods of estimating composition and condition, and a few general methods of qualitative and quantitative analysis. The Appendix is a six-page table summarizing some nondestructive methods of examination; this table is keyed to the descriptive matter in the text. Many references to more detailed treatments of the methods are given at the ends of chapters. Name and subject indexes have been provided. Dr. Hanstock, the author, is Chief Physicist, High Duty Alloys, Ltd.

NAVIGATION

The Sciences in Navigation. A Symposium of Papers Presented at the 7th Annual National Meeting of the Institute of Navigation, New York, June 28, 29, 1951. Los Angeles, Institute of Navigation, University of California, December 1951. 96 pp., diagrs., figs.

Introduction to Symposium, Paul Rosenberg, Physics in Navigation, Louis N. Ridenour. Mechanics in Navigation, John E. Clemens. Optics in Navigation, Robert E. Hopkins. Mathematics in Navigation, Charles H. Smiley. Electronics in

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Navigation, P. C. Sandretto. Communication Theory and Navigation, J. R. Pierce. Astronomy in Navigation, G. M. Clemence. Cartography in Navigation, Robert F. A. Studds. Oceanography in Navigation, Edward H. Smith. Meteorology in Navigation, Jerome Namias. Zoology in Navigation, Talbot H. Waterman. Psychology in Navigation, Clifford P. Seitz. Flight Simulators in Aircraft and Missile Dynamic Studies, Harold K. Skramstad.

PRODUCTION

Manufacturing Processes. Myron L. Begeman. 3rd Ed. New York, John Wiley & Sons, Inc., 1952. 608 pp., illus., diagrs., figs. $6.00.

New chapters in this edition are the Introduction, Cold Forming of Metals—Miscellaneous Processes, and Cold Forming of Metals—Press Work. In addition, the chapters on Special Casting Methods, Plastic Molding, and Welding and Allied Processes have been rewritten with much new material added. The book has been revised throughout, and most of the illustrations are new. Approximately one-half of the book is devoted to foundry practice, pattern work, plastic molding, powder metallurgy, hot- and cold-working of metals, heat-treatment, and welding. The remainder of the book is given over to measuring instruments, cutting tools, machines, and their accessories.

The Metco Metallizing Handbook. H. S. Ingham and A. P. Shephard. 5th Ed. Long Island City, N.Y., Metallizing Engineering Company, Inc., 1951.

This summary of technical and practical data on the process of forming surface coatings by spraying molten metal is divided into eight parts. In the first part, the history and general aspects of the metallizing process are treated briefly. Chapters 2 and 3 are concerned with the building up of machine elements and the application of metallized coatings for corrosion resistance. In Chapter 4 are discussed metallizing (as applied to holes in castings), brazing, soldering, glass, ceramics, mass coatings, nonmetallic materials, model work, and electric circuits. The remaining chapters deal with the Metco Sprayweld process, engineering data and tables for sprayed metal, work-space ventilation, and safety measures. There is an index of topics covered.

REFERENCE WORKS

Lexicon of Terms Used in Connexion with International Civil Aviation, English-French-Spanish. (I.C.A.O. Document No. 7200). Montreal, International Civil Aviation Organization, 1952. 197 pp. $1.00.

This lexicon brings together a number of terms relevant to the work of I.C.A.O. In addition to terms relating to aircraft design and operation, aerodrome construction, and air traffic control, terms are also included which belong to the fields of aeronautical cartography, communications, and meteorology. In its present form, the compilation is incomplete and, in part, tentative. It contains a total of approximately 2,500 entries with the French and Spanish equivalents. In 625 entries, definitions have also been given. Three appendixes list the main categories of international aviation, a classification of aircraft, abbreviations, notations for units and parameters, and units of measurement.

Whites Air Directory and Who's Who in New Zealand Aviation (Including the South Pacific). Vol. 5, 1951–52. Compiled and Edited by Norman E. Smith. Auckland, N.Z., Whites Aviation Limited, 1951. 184 pp. 10*s*. 6*d*.

Material included covers military and civil governmental agencies, manufacturing companies, air-line companies, airports, registered aircraft and pilots, maintenance and supply agencies, trophies, scholarships, school, and flying clubs.

ROTATING WING AIRCRAFT

Proceedings of the 8th Annual Forum, American Helicopter Society, Washington, May 15, 16, 17, 1952. American Helicopter Society, Inc., 2 East 64 Street, New York 21, N.Y., 1952. 200

pp., illus., diagrs., figs. $5.50 (Members of the American Helicopter Society, $3.50).

Maintenance Session: Problems in Korean Helicopter Maintenance and Their Relations to the Service Representative, Harold Nachlin. U.S. Army Helicopter Maintenance Experience in Korea, George L. Lovett. Design for Maintenance, Phillip W. Kerr.

Flight Operations Session: Korean Rescue Operations, John J. Dean. Helicopter Operations in Alaska, Gene L. Douglas. Helicopter Operation for Patrol of Power Lines in Remote Areas, T. J. Burgess. Role of Transport Helicopter in Metropolitan Areas, Jack Rethman.

Theory and Design Session: The Effect of Blade Mass Constant and Flapping Hinge Offset on Maximum Blade Angles of Attack at High Advance Ratios, John R. Meyer, Jr., and Gaetano Falabella, Jr. Some Remarks on Dynamic Stability of the Helicopter and Characteristics of Gyratory Stabilizing Systems, G. J. Sissingh. An Analysis of the Helicopter Transfer Function To Predict Achievable Handling Characteristics of the Stabilized Helicopter, Edward Sterling Carter, Jr. Comparison of Helicopter Rotor Propulsion Systems, Joseph Stuart, III.

Development and Test Session: Some Aerodynamic and Dynamic Problems of the Compound Rotary-Fixed Wing Aircraft, Kurt Hohenemser. Development of High Lift Airfoils by Boundary Layer Control, Kenneth Razak. Air Force Testing and Evaluation of Helicopters, Wayne W. Eggert.

SCIENCES, GENERAL

CHEMISTRY

The Physical Chemistry of Surface Films. W. D. Harkins. New York, Reinhold Publishing Corporation, 1952. 413 pp., illus., diagrs., figs. $10.

The present text covers all of the author's fundamental pioneer work on the mechanism of liquid-liquid films and interfaces, surface tension, emulsification, energetics of surfaces, the nature of films on liquid and solid subphases, and properties of solutions of long-chain electrolytes. Also included is an introductory study of the electric layer by E. J. W. Verwey. The volume should be of assistance to workers in the fields of plastics and rubber, lubricants, paints and oils, emulsions, and foams and films. In addition to the extensive lists of references following each section, there are a chronological listing of the works of Professor Harkins (270 references) and a lengthy subject index. At the time of his death in 1951, the author was Andrew MacLeish Distinguished Service Professor Emeritus at the University of Chicago.

MATHEMATICS

Conformal Mapping. Zeev Nehari. New York, McGraw-Hill Book Company, Inc., 1952. 396 pp., figs. $7.50.

This text is intended to fill the gap between the theoretical approach of the pure mathematician and the more practical interests of the engineer, physicist, and applied mathematician who are concerned with the actual construction of conformal maps. A good working knowledge of calculus is required of the student. The potential theory and complex function theory necessary for a full treatment of conformal mapping are developed in the first four chapters. The remaining three chapters are concerned with the conformal mapping of simply connected domains, the mapping properties of special functions, and the conformal mapping of multiply connected domains. A large number of problems and exercises and an index of subjects have been included.

Conformal Representation. C. Carathéodory. 2nd Ed. London, New York, Cambridge University Press, 1952. 115 pp., figs. $2.50.

Principal changes in this edition are the addition of a chapter on the general theorem of uniformization of Poincaré and Koebe and a new compilation of the Bibliographical Notes of the first edition (1932).

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397. Engineers—Established manufacturing concern now staffing new engineering department for development programs in propulsion and rotating machinery field. Experience in turbojet, ram-jet, and rocket design and development desirable (all phases). Permanent positions at attractive salaries for those who qualify. Bonus plan. San Fernando Valley (Los Angeles Area) location. Give complete education, professional experience, professional responsibility, and salary history in first communication.

390. Design Engineer—With solid background in layout and design of high-speed rotating machinery to work in development and production of commercial gas turbines. Should be able to follow up design through drafting room and assist draftsmen in solving problems involving patternshop, foundry, and machine-shop practice. Salary, $8,000 to $10,000, depending on record and experience. New York State location.

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400. Civil Engineer—B.S. in C.E., 1942. Age 31. Private pilot's license. Experience: Aircraft stress analysis 2½ years; engineering instruction 2 years; field engineering and construction 2½ years to date. Desires work in foreign construction. Must be able to travel with wife. Available in August.

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395. Aeronautical Research and Development Engineer—B.Ae., M.S. in Ae.E. Excellent theoretical background. Almost 7 years' experience in dynamics, aeroelastics, stability and control of fixed- and rotary-wing aircraft, missiles. Presently employed in helicopter aeroelastics. Desires responsible position in research and development. Specify nature of position in first letter.

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392. Aeronautical Engineer—B.S. in Ae.E. Well-rounded background of 15 years of military aircraft design, supervisory and administrative experience, including 5 years of guided missiles experience. Seeking new connection in design supervisory, executive, or administrative capacity in aircraft, missiles, or any allied field. Past experience includes positions as Project Engineer, Assistant Project Engineer, Chief Draftsman, Chief Standards Engineer, Power-Plant Group Leader, Armament Group Leader, and many others.

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